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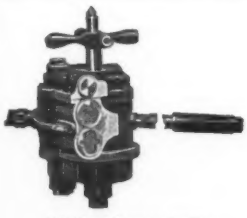
Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. IX. NEW YORK, JUNE, 1904. No. 4



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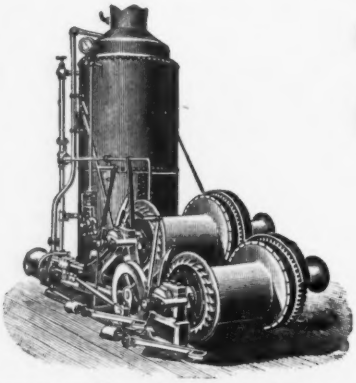

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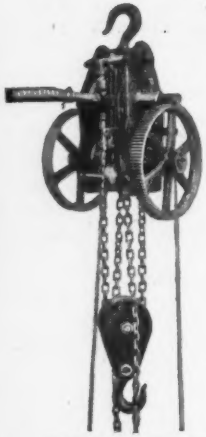

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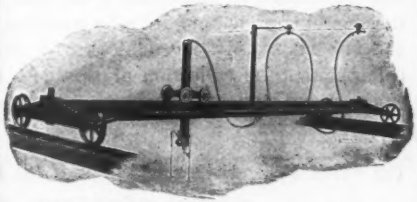

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EDITED BY

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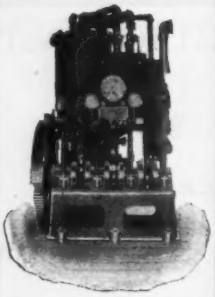

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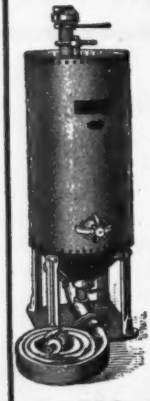

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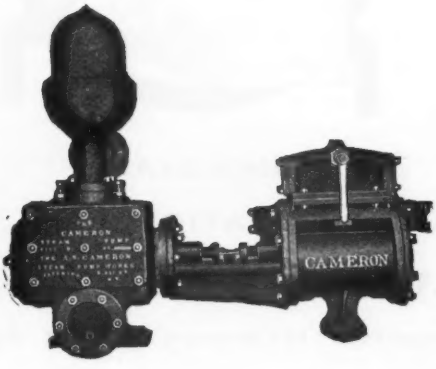

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VOL. IX. JUNE, 1904. NO. 4

Cleaning by Compressed Air.

Cleaning by compressed air has already received much attention in this publication and a number of methods have been described. Generally speaking, they may be all divided into two classes—the compressed air spray, and the suction cleaner. Both are in operation at the present day, but the greater success seems to have been achieved by the methods in which the air under pressure plays an all important part.

No one can question the efficacy of air under pressure for cleaning. The chief objection has been that the particles of dirt and foreign matter were blown out of one resting place only to find another. To surmount this difficulty, various devices have been tried. A receiver has been utilized in which is collected the dust. A combination has also been effected between the compressed air and suction systems, whereby the former is used to blow out the dirt and the latter to receive and carry it away.

Among the first to adopt compressed air cleaning on a large scale was the Pullman Company. Until compressed air offered its advantages, the problem of cleaning drawing-room and sleeping cars quickly but thoroughly was one of the most troublesome which confronted that company. A simple compressed air spray was first utilized and was a great improvement over the old methods. Recently the Pullman Company has made a series of tests of various devices now on the market with a view to bring out any which would improve the present service. The results of these tests were in favor of the compressed air cleaners as against the suction methods.

The Pullman Company has not made public, however, any of the comparative facts and figures secured at the test so that it is impossible to know what were the exact results.

The last year has seen a number of firms engaged in the cleaning of carpets by compressed air. The speed and simplicity of this method of cleaning has been its attraction, but most important was the freshness and cleanliness given to all carpets and other fabrics which receive this treatment. Dull colors were brightened, while the fabric suffered no injury.

Another field which promises to see a very large development in the near future is the cleaning of houses by compressed air. Carpets can be taken to the cleaners, but it is necessary for the cleaner to have

a portable equipment for operating in houses. Hotels and public institutions have already found this service invaluable, and it promises in time to supersede all the horrors of the old-fashioned "house-cleaning" at the private home. Several house-cleaning companies have already operated in New York, but litigation over controlling patents has held the industry in check, until, at the present day, the west is considerably ahead of the east in this direction. It is, however, only a question of a few months before house-cleaning companies, using compressed air supplied from portable outfits, will be in general operation.

The growth of this industry means a development in portable air compressors to meet the principal demands of this service. Lightness, size and simplicity of operation will be all important factors. An air compressor for this work must be capable of running with little or no attention and to be so regulated as to keep up the supply and pressure to meet the changing conditions. In the case of large establishments, an electrically driven compressor is practical, but for general operation the gas engine is the only feasible means of supplying power. Several small air compressors, which in a measure answer the requirements, are manufactured at present, but any extensive use of this portable equipment will undoubtedly result in the design and manufacture of a type which will more nearly meet the requirements and give better and more satisfactory results.

Compressed Air at the Louisiana Purchase Exposition.

Many eyes are now turned toward St. Louis, where the Louisiana Purchase Exposition opened Saturday, April 30. For those who are interested in the progress made in compressed air appliances, St. Louis will be an interesting city this summer. While all the companies dealing in pneumatic appliances are not represented among the exhibitors, those which have taken space are showing their latest applications and improvements to standard machines which combine to form an important display. More interesting to many than the exhibits themselves will be the practical demonstrations of the usefulness of this means of power transmission. In the construction of the Exposition buildings, in the operation of many features at the Exposition, and for various uses in the city of St. Louis itself, compressed air has figured and will continue to figure prominently.

In St. Louis, elaborate preparations have been made to care for the throng that is expected to visit there this summer. Terminal facilities have been greatly increased by the principal railroads, and there compressed air finds a most important field. For the regulation and control of the switches and signals the largest electro-pneumatic plant of its kind is being installed. To handle the local traffic the St. Louis Transit Company has increased and improved its equipment. Here, for the first time on any large system, the storage air brake is being operated. Its success under the unusually severe requirements,

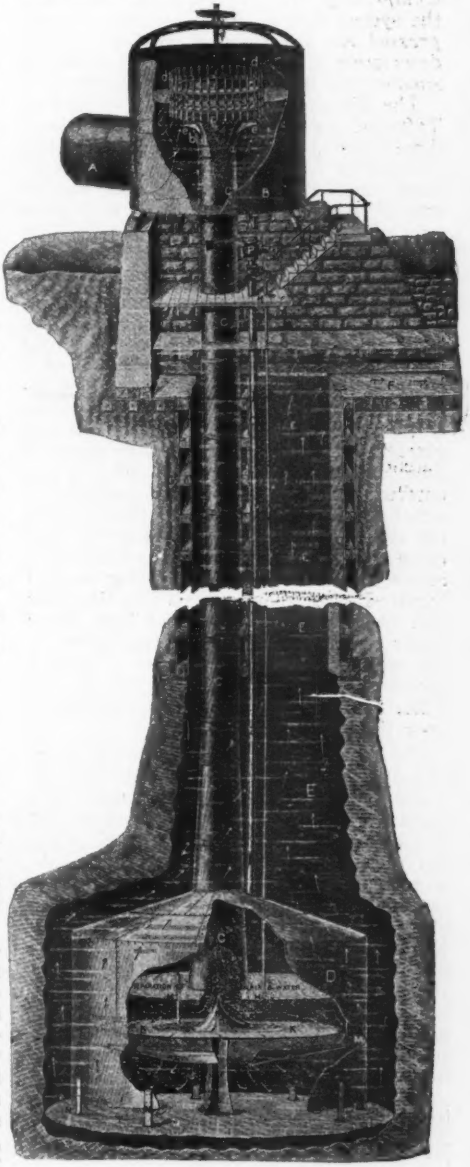
will be studied by street railway men from all over the country. The postal officials at St. Louis expect a vast quantity of mail, and, to handle it expeditiously, a pneumatic tube system is being built. This will connect the railway terminals with the main station and sub-stations and save many minutes in delivery, besides reducing the labor of handling.

Here are three ways in which compressed air will figure prominently in St. Louis this summer and this list is not complete. COMPRESSED AIR has already described several important compressed air installations at the Missouri city. Further attention will be paid to this subject during the summer, and readers of this paper may expect to be kept posted as to the events of interest at the World's Fair, in which compressed air takes part. Readers of this magazine who visit the Exposition are invited to write concerning any of the features already noted, or others of interest which they may find.

Air Compressor Plant at Norwich, Conn.

There has recently been put into successful operation at Norwich, Conn., an air compressor built upon the Taylor system, which from size and novelty deserves notice by engineers and those interested in compressed air.

The Taylor air compressor consists essentially of a vertical tube down which flows a stream of water and a large number of small short tubes whose lower ends are immersed in the water, their tops being open to the air. The water passing by the ends of the tubes creates a suction and carries a quantity of air down the main tube with it. At the bottom is a large chamber where the air and water separate, the water passing off beneath the lower edge and the air being taken away through a pipe at the top of the chamber. The air pressure desired is obtained by submerging the separating chamber a sufficient



THE TAYLOR HYDRAULIC AIR COMPRESSOR.

depth beneath the surface of the water in the tail race.

The accompanying cut, taken from *Compressed Air Information,* illustrates the system clearly. On page 166 of *Compressed Air Information* will be found a description of a similar compressor but of smaller size in use at Magog, Quebec.

The Norwich compressor is located at Taftville, on the Quinebaug river, about three miles above the city of Norwich, and is rated at 1,500 horse-power. Its maximum capacity is about 12,000 cubic feet of free air per minute compressed to a pressure of 90 pounds. With 23 foot head of water about 800 cubic feet of water per second is used.

With a 1,500 horse-power compressor is usually associated in one's mind a fine large engine-room, well filled with moving machinery, so that the first view of this power-house is somewhat disappointing. A small, low building perched upon one end of the dam, to all appearances the gatehouse and much smaller than many of them, is the only building in sight. Upon entering this one sees a vast quantity of water flowing in from the forebay toward the center and disappearing down a tube some 10 feet in diameter. Suspended above this is a frame supporting several hundred tubes about one inch in diameter and some two or three feet long, their lower ends immersed for a few inches in the water. These are the air tubes and the strong suction action exerted by the water can be easily felt by placing a finger upon the top of one.

The flow of water is controlled by a set of gates which can be controlled either by a small turbine wheel or by hand. The vertical tube extends downward some 225 feet below the surface of the water in the tail race in order to get the proper submergence for the 90 pounds air pressure required. In the separating chamber is a blow-off pipe several inches in diameter. Normally the bottom of this is sealed by the water in the chamber, but should a surplus of air accumulate the water level falls and the air passes off through the pipe. This stream of air and water is shot some 200 feet and looks as though a small geyser were at work.

From the compressor a 16-inch cast-iron pipe carries the air to the city of Norwich where it is distributed to several mills and other power users.

A very noticeable feature of the air is its absolute dryness. A looking-glass held against a jet of it will not show a trace of moisture.

It is claimed to carry less than one-third of the moisture of air compressed by any other means and to have been thoroughly washed and cleansed by its intimate mixture with water during compression.

This is borne out by its use by a doctor who covers his patient's face with a mask which is connected by a tube to the compressed air main.

Breathing this air for certain periods each day is said to have proved very beneficial in building up patients who have been badly run down.

In a recent number of the *American Machinist* appeared a note that the fire department had successfully operated their engines by connecting them to the air mains which are laid in many of the streets.

It is proposed to arrange some pumps on wheels to act as auxiliary fire engines. Comment was made that although the pipes around the engine became coated with frost no trouble was met with from the engine freezing up. This is no doubt due to the extreme dryness of the air, as there cannot be frost or ice without moisture.

At present the air is chiefly used by the mills in engines of from 100 horse-power down. These engines were formerly operated by steam and are generally of the slide valve, throttling governor type, and use much more air than they should, but any engines installed in the future will no doubt be of a construction economical in the use of air. The charges at present are arranged for each individual case, but it is hoped shortly to get upon a meter basis.

Reheating has been little used up to date, but the company hopes to develop this side in the near future. These economies will be reached in time, but as it stands now there is being supplied to the city of Norwich a constant supply of compressed air to the extent of 1,500 horse-power day and night by a plant as nearly self-operating as can well be, the only attendance being one man at the dam to handle the gates and generally look out for everything at that end.

At the time of a visit made during one of the coldest days of last January, though the river was coated with ice and a snowstorm raging, there seemed to be no

trouble experienced either with floating ice or freezing.

The extreme simplicity of the plant and lack of mechanism to be maintained is very impressive, and leads one to feel that the system has great possibilities in the near future.

A very complete description of the dam and hydraulic side of this plant, written by Mr. H. M. Knight, resident engineer, will be found in *Engineering News,* page 470, volume 47.

This plant has been installed and is being operated by the Continental Compressed Air Power Company, of Norwich, Conn.

WARD RAYMOND.

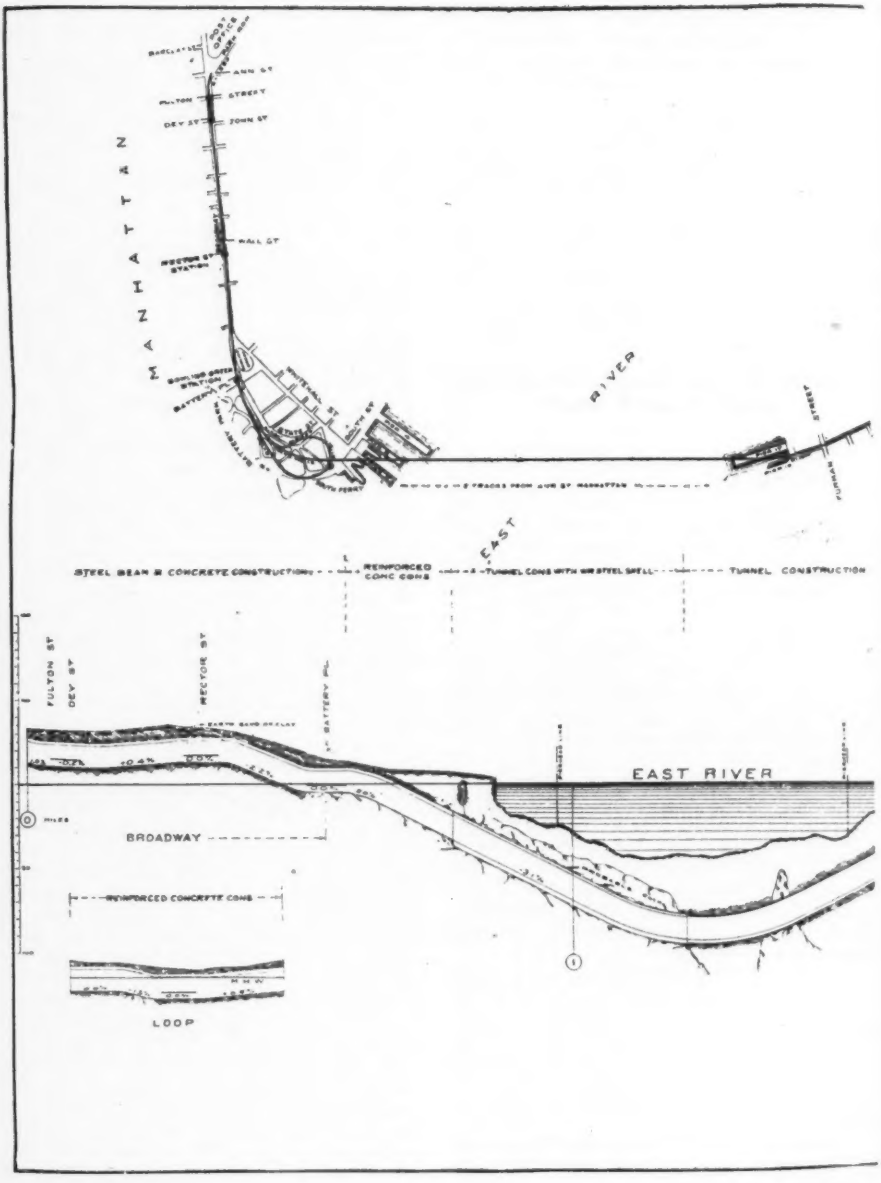
The New York and Brooklyn Tunnel for the Rapid Transit Railroad.*

The subway of the Broadway extension of the Rapid Transit Railroad is to be connected with the Brooklyn subway by two parallel single-track tunnels crossing the East river from the Battery Park loop to Pier 17, Brooklyn, and thence under Joralemon street to a connection with the Fulton street line. Each tunnel has a cylindrical cast-iron shell lined with beton, and has a clear inside diameter of 15½ feet. The tubes are about 25 feet apart on centers, and have a total length of about 6,550 feet and a maximum depth of about 94 feet from mean high-water level to base of rail. The maximum depth of water is about 50 feet and the thickness of the roof above the tubes varies from about 6 to 30 feet. The maximum grades are 3.1 per cent. and are connected by a vertical curve under the middle of the river. The location and character of the materials encountered differ essentially from the indications afforded by the preliminary exploration.

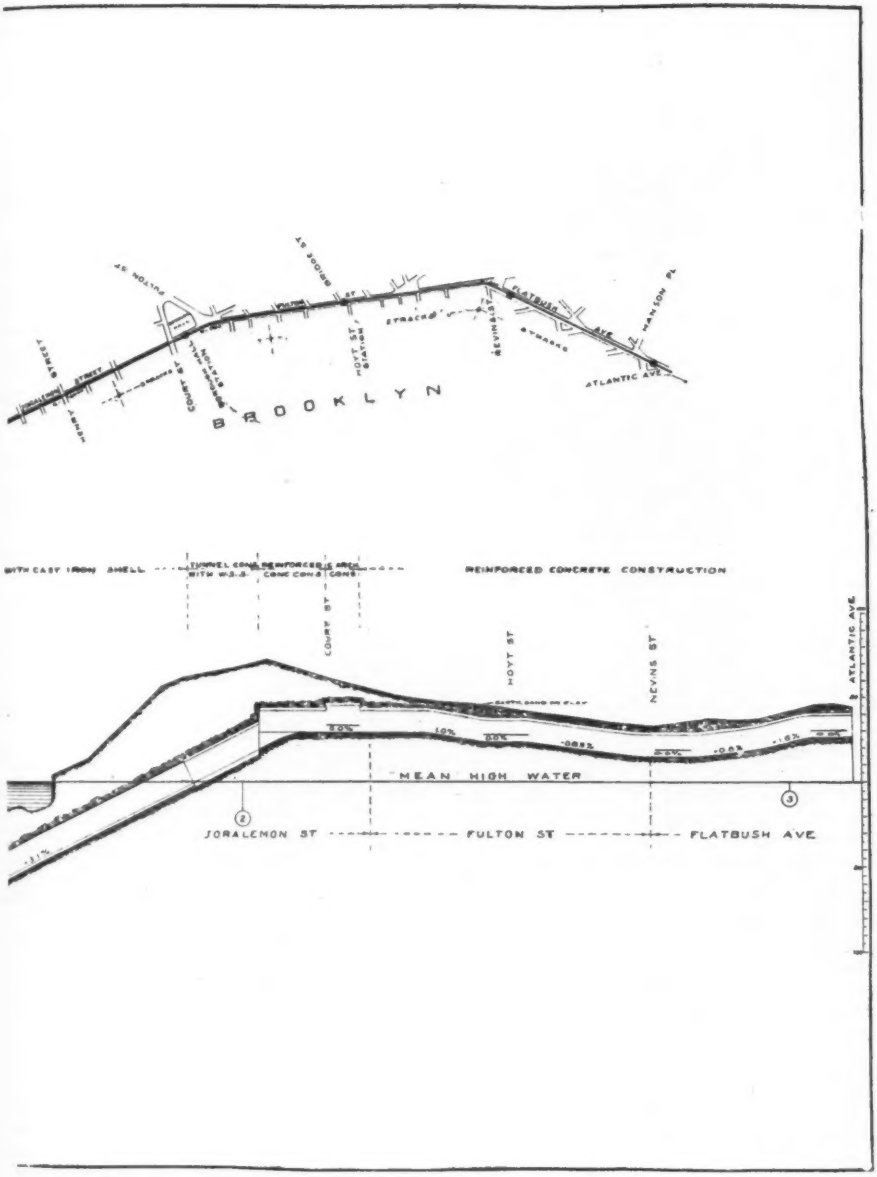
On the New York side the excavation has progressed for about 500 feet, all of it through solid rock of variable character, some being hard and some soft or decomposed, with numerous irregularities, fissures and open seams. The surface undulates within limits of about 10 feet vertically. At present the New York headings have only about 2 feet of shaky rock over them, and above the rock there is only 6 feet of clay, boulders and other loose material, thus making the excavation a delicate operation. On the Brooklyn side, while about 1,200 feet of tunnel have been built landward, the river headings have advanced about 500 feet from the shaft in one tube and 200 feet in the other, neither of which have yet reached the shore line. Here the excavation has been wholly in sand and gravel, and at present is being accomplished with special steel shields and without air pressure. On the New York side no shields are used, but the work is being executed under a pressure of about 10 pounds, equivalent to the hydrostatic head, due to the depth of the river at the headings.

The New York headings are being driven from a 53 by 15 foot shaft about 42 feet deep, braced and sheeted with timber in the ordinary manner. It contains two separate elevator shafts and is surrounded by an enclosure which reserves a portion of the east end of Battery Park, under the elevated railroad tracks, for the installation of the surface plant, storage of materials, repair shops, offices, derricks and spoil tracks. Both drifts are being made with ordinary upper headings about 8 feet high and of the full width of the excavation. The rock is so treacherous that the roof is supported, as fast as the excavation is made, with 3-inch poling boards and bents of arch timbering 5 feet apart on centers. Each bent consists of a horizontal center piece and two inclined end posts with miter joints. Each piece is a 12 by 14 inch timber 8 feet long. Four Ingersoll-Sergeant and Rand rock drills are used in each heading to bore holes about 6 feet deep by means of which the rock is blasted by light charges of dynamite carefully proportioned to avoid lifting the thin roof. The upper holes for the center cut are drilled but not fired before the center arch timber is set, because they are so near the roof that the timber would otherwise interfere with the drills. After these holes are finished, the center timber is temporarily supported on the horizontal arms of the drill columns, and the remainder of the holes are drilled. Afterwards the sides of the drift are taken out and the inclined side posts of the bent are inserted. A bench about 12 feet high is taken out in the usual way

* A description of the Compressed Air Equipment at the Brooklyn tunnel was given in COMPRESSED AIR, December, 1903. The plan and profile on pages 2963 and 2964 were published in that issue. The other illustrations are given through the courtesy of the *Engineering Record.*



PLAN AND PROFILE OF



TUNNEL AND CONNECTIONS.

and is kept from 20 to 30 feet distant from the heading. Where the roof is very thin, special care is taken to pack hay tightly in the cavities over the forward ends of the poling boards as fast as they are advanced so as to prevent the flow of sand and earth which crumbles very easily. The finished iron shell is kept as close as possible to the end of the finished excavation, usually being not more than 20 feet behind it. As fast as the shell is assembled, all the spaces between it and the rock are carefully packed with dry stone laid as closely and solidly as possible. The interstices among these stones are afterwards thoroughly filled with grout at a pressure of 90 pounds per square inch, thus making a concrete sleeve for the shell, which would have considerable strength if the shell were entirely removed and through which there is even now scarcely any leakage.

The shell is of the ordinary construction with eight main segments about 6½ feet long and a crown segment or key about 1 foot long. Each segment is 22 inches in width and is made of 1⅛-inch metal with flanges on all sides 7 inches deep over all. The flanges are bored for three 1-inch bolts in each end and six on each side; they are 1⅛ inches thick at the edges and are stiffened by knee-brace webs. The segments are put together without gaskets and have bearings on planed surfaces 5 inches wide. The outer 2 inches of each flange are recessed so as to make calking spaces ¼ inch wide. Each segment is made with a short inside longitudinal web in the center, having two bolt holes to facilitate handling it during assembling. There is also a 1½-inch hole tapped through the web which is normally closed by a screw plug and affords connection for the 1¼-inch grouting pipe. The segments are delivered by boat to the cars on a double-track trestle which crosses Battery Park from the water's edge to the shaft. There they are unloaded by a stiff-leg derrick and lowered by the elevator car in the shaft. From the foot of the shaft they are sent to the heading on small platform cars, which deliver them to a special machine called an erector. The erector has a horizontal platform about 14 feet wide on the center line of the tunnel which is movably supported on the flanges of the shell. This platform carries a radial arm which is revolved by an air motor about a horizontal pivot in the axis of the tunnel. The extremity of the arm is bolted to the 900-pound segment of the shell and revolved into the required position. An hydraulic piston in the arm then pushes the segment out to place, and it is bolted through two flanges; another segment is added and so on until the ring is complete. The erector weighs only about 3 tons, is simple in its operation and is considered very efficient and satisfactory. With it four men can assemble one ring of the shell in about 1 hour.

The assembling gang is followed at a distance of from 50 to 100 feet by the grouting gang of three men. The grout machine is operated by an Ingersoll-Sergeant three-cylinder air engine. It consists of a small air-tight cylinder in which six bags of cement and crusher dust are mixed by revolving paddles, and from which the mixture is expelled by air pressure.

About 100 feet from the foot of the shaft each tube is closed by a solid mass of brickwork about 6 feet thick apart. Built into them are the two air locks, the lower one 6½ feet in diameter and 20 feet long is chiefly for the passage of cars and materials. The upper one, 3 feet in diameter and 32 feet long, is for the passage of men and to admit long timbers, rails, pipes, etc., without excessive loss of air. It is also designed to be always available as an emergency lock. The spoil is loaded at the heading into 1-yard steel cars having special trucks of 30-inch gauge. Each axle is keyed to one wheel and loose in the other wheel, and is enclosed by a sleeve, the space between the axle and sleeve being filled with oil for automatic lubrication. Both these cars and the platform cars run from the foot of the shaft to the heading by gravity and are pulled back by a steel wire cable operated by a single-drum Lidgerwood hoisting engine seated on the overhead platform. Each tube is lighted by groups of three incandescent lamps at intervals of about 50 feet, besides additional lamps at the different machines and in the heading and shaft. These lamps are connected to a three-wire system arranged with a loop so that all lamps may have the same potential. A 110-volt current is used so as to avoid all danger of accident and insure safety even in handling the naked wires.

There is not much water in the heading, and it is easily expelled through a

NEW YORK AND BROOKLYN TUNNEL: TIMBERING IN NEW YORK HEADING.

blow-out tube by the air pressure, thus avoiding any necessity for pumping there. The blow-off delivers to a sump at the foot of the shaft, whence the water is raised to the surface by steam pumps. With the exception of these pumps, all machinery in the tunnels is operated by air at 90 pounds pressure.

stone, which is used to fill between the flanges of the segments. From 9 to 12 men are required in each heading; about 225 men in all are employed on the New York side and 100 on the Brooklyn side in the tunnels. The work is done with three eight-hour shifts daily, and a maximum progress of 12 feet in 24 hours has

IRON LINING, ERECTOR AND BULKHEAD PROTECTION AGAINST BLASTS IN HEADING.

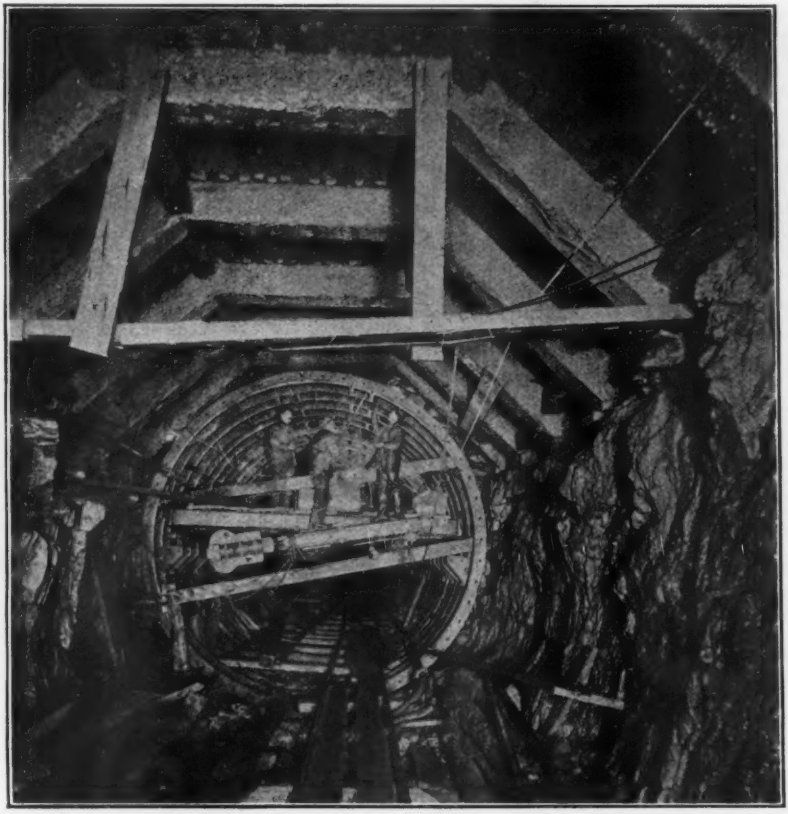
The principal quantities per linear foot of each tube which are involved in the construction of the tunnel include 9 cubic yards of excavation in rock and 8¼ yards of earth in shield work, 120 feet board measure of timber for rock excavation, 4,000 pounds of cast-iron in the shell and about 21 cubic feet of 1:3:4 Giant Portland cement concrete made with ¾-inch

been made in the shield tunnels and 3 feet in the rock tunnels.

The contractors' plant in the tunnels on both sides of the river includes fourteen Rand and Ingersoll-Sergeant rock drills, fifty 1-yard mine cars, four Lidgerwood hoisting engines, ten Cameron pumps, four shields, made by Alexander Miller & Bro., of Jersey City, six erectors, two

grout machines, four material locks and four emergency locks made by the Cockburn Barrow & Machine Company, of Jersey City, and six hydraulic pressure pumps operating the erectors, besides the hydraulic machinery for the shields, which was made by the Watson-Stillman Company, of New York.

ter cooler and a 6 by 15 foot receiver, supplying air to the heading under a present pressure of about 10 pounds; two Ingersoll-Sergeant straight line compressors with a capacity of 1,200 cubic feet of free air per minute which supply air at 100 pounds pressure to operate the machinery in the tunnel; one General Elec-



ASSEMBLING SECTION OF LINING WITH ERECTOR—LOOKING FROM HEADING.

The surface plant at the New York end includes a 650-horse-power battery of Hogan boilers; one Bacon hoisting engine, driven by compressed air, operating the balanced cages in the shaft; one 500-horse-power Ingersoll-Sergeant air compressor with a capacity of 3,000 cubic feet of free air per minute, fitted with an intric Company's and one Keystone direct-connected 17-kilowatt 110-volt dynamo; one direct-connected Westinghouse 40-kilowatt 100-volt dynamo; one 16 by 10 inch Farrell 50-yard stone crusher, driven by a 9 by 10 inch Vim engine, and a 10-inch bucket elevator 40 feet long on centers which delivers the crushed stone and

dust to 10 by 10 by 11 foot elevated bins. There is also a buzz-saw for cutting the arch timbers and some machine shop tools for repair work, which are driven by a 10 horse-power Ames steam engine. On the Brooklyn side power is furnished by five Gem City 125 horse-power horizontal tubular boilers and by a battery of 500 horse-power Heine boilers. There are one large and two small compressors like those on the New York side; two Keystone direct-connected 32-kilowatt 110-volt dynamos; two separate Bacon hoisting engines for the shaft elevators; and small tools for the repair work similar to those installed on the New York side.

The Brooklyn headings have been driven from two 24 by 20 foot shafts about 65 feet deep and 50 feet apart on centers sunk and timbered as described in *The Engineering Record* of October 31, 1903. The soil at this point was found to be sand and gravel with small boulders, and as it could not be depended on to stand up for the sides of the excavation, shields were installed as soon as the shafts were sunk. These shields are of riveted steel about 17 feet in diameter and 9½ feet long, including the tail-piece and exclusive of detachable hood and central platform extension. They differ in several respects from shields previously used for tunneling and were especially designed by Chief Engineer Aims to meet the conditions which were expected to prevail in this work. Patents on the novel features have been applied for and include the removable hood, special working platforms and bracing in the front of the shield and horizontal sliding doors in the transverse diaphragm, which are operated by hydraulic cylinders.

The cylindrical iron shells were delivered in four sections each and assembled with the girders and diaphragms at the bottoms of the two shafts. When they were completed, special bracing was built in the shaft lining and the lower portion of the sheeting and timber work was cut out to allow the shields to be driven through the walls. The first two shields were driven away from the river to the shore end of this section of the subway, where they now remain and may either be utilized by the contractors for the adjacent section or may be removed. After these shields had been driven clear of the shafts, two more shields, duplicates of the first, were assembled in the bottoms of the shafts and were driven in the opposite direction on the line of the tunnel under the river. These shields have now been advanced about 500 feet from the shafts, and air locks similar to those described for the New York side have been built behind them about 100 feet from the shafts. The shields are driven in the usual manner by hydraulic jacks operated by pumps carried on the erector platforms and worked by air at 100 pounds pressure.

The water encountered in the headings is pumped to a sump at the foot of the shaft and then repumped to the surface. The lining and grouting is carried on in a manner similar to that described for the New York side.

The design and construction of the tunnel is under the supervision of Mr. William Barclay Parsons, chief engineer of the Rapid Transit Railroad Commissioners for the City of New York; Mr. George S. Rice, deputy chief engineer, and Mr. Robert Ridgway, division engineer. The contract for this section of the subway was awarded to the Rapid Transit Subway Construction Company, Mr. J. B. McDonald, President; Mr. S. L. F. Deyo, chief engineer, and Mr. Harry B. Reed, division engineer. A sub-contract for the tunnel construction was let to the New York Tunnel Company, Mr. Andrew Onderdonk, contractor; Mr. Walton I. Aims, chief engineer; Mr. John Kergan, superintendent. Mr. Bernt Berger has assisted Mr. Aims in the preparation of some of the detail plans for the structural work.

The four special shields used in the excavation at the Brooklyn end of the tunnel are 16 feet 11¼ inches in diameter and 9½ feet long over all, exclusive of a removable hood about 3½ feet long. The design corresponds in general appearance to cylindrical steel shields used for previous tunnel work, but differs from them in a number of new improvements adopted to surmount the difficulties anticipated. The cylindrical shell of the shield is made double with an outer plate ⅝ inch thick and an inner plate ½ inch thick riveted together. About 5 feet from the forward end of the shield, there is a vertical transverse bulkhead made of a steel plate ⅞ inch thick stiffened by a framework of vertical and horizontal angles. In front of the diaphragm and about 39 inches from it, the shell is stiffened by an annular girder about 22

inches deep. The inner flange of this girder is connected with the diaphragm by a steel cylinder about 14 feet in diameter and concentric with the shell. The annular space between this cylinder and the shell is divided by fourteen radial longitudinal diaphragms, and the spaces between them serve as chambers for the hydraulic jacks. In the plane of each longitudinal diaphragm there are knee-braces connecting the inner cylinder with the transverse diaphragm and connecting the annular girder with the outer shell and the conical plate.

The cutting edge of the shield projects 20 inches beyond the annular girder and is braced to the inner flange of the latter by a ¾-inch conical plate with its bent edges riveted to the shell and to the girder. The rear end of the shield projects about 4½ feet beyond the diaphragm and this portion of it serves as a tail-piece engaging the permanent iron shell of the tunnel, which has a clearance of 1 inch reduced by the thickness of a 7 by ¾ inch flat riveted to the inner side of the shell around the upper third of its circumference at the rear end to serve as a sort of packing piece. Just above the center of the shield, there is a horizontal platform reaching from the diaphragm to the cutting edge. It is made of ¾-inch plates supported on 15-inch channels, serves as a working floor for the excavators and is accessible through a door in the diaphragm about 4½ feet high and 4 feet wide. A corresponding door symmetrically placed just below the working

ERECTOR, NEW YORK SIDE, LOOKING TOWARDS AIR LOCK.

platform gives access to the cutting edge in the lower part of the shield and both together may be considered as a single opening crossed by the working platform. Each of these two doors is closed by a pair of steel-plate shutters sliding in horizontal top and bottom guides attached to the diaphragm. When open, they are close to the diaphragm on either side of the shield; when closed, they meet on the center vertical line of the shield. They are operated by hydraulic cylinders commanded both by the men in the shield and from a point outside the air lock so that in case of accident or emergency they can be closed after the tunnel is abandoned. The shutters are made of solid plates ⅞ inch thick reinforced by pairs of vertical Z-bars extending from top to bottom to resist heavy horizontal pressure. The lower edges run in grooves 1⅛ inches wide between bearing strips on the diaphragm and the horizontal flanges of 9-inch deck beams which are riveted across the bulkhead diaphragm to resist flexure. The opposite face of the diaphragm is stiffened by pairs of vertical 6 by 3½ inch angles. A semi-circular removable hood about 3½ feet long is provided which can be bolted to the upper part of the shield so as to project still further into the soft earth and afford additional protection for miners working on the face. It is built like the shell of the shield of an outer ½-inch plate and an inner ⅞-inch plate reinforced by a flange angle on the cutting edge of the shield. It is also stiffened by five inclined shores from the outer edge to the front part of the elevated working platform.

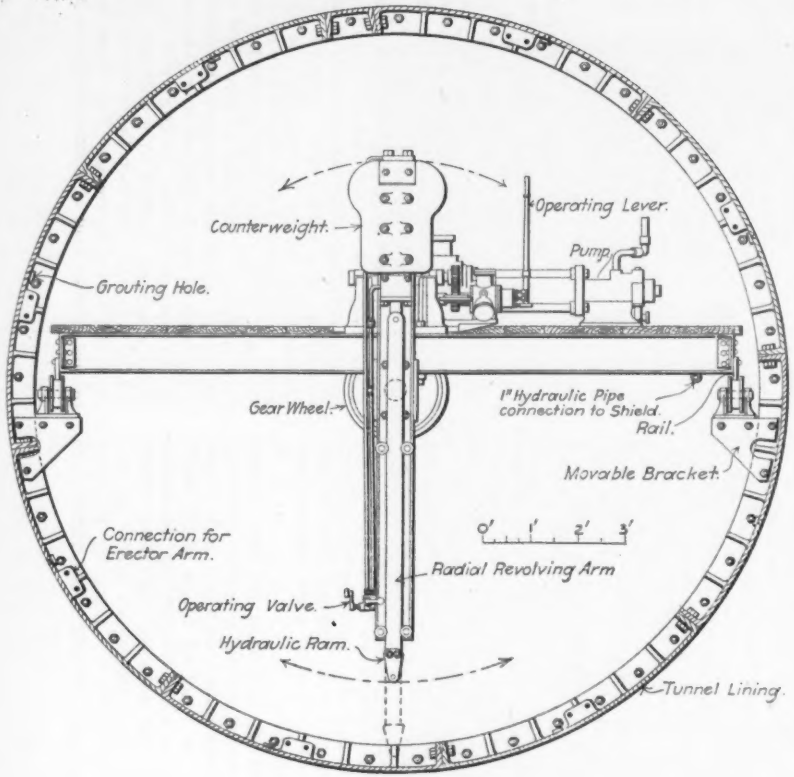
ERECTOR AND REAR OF SHIELD, BROOKLYN SIDE.

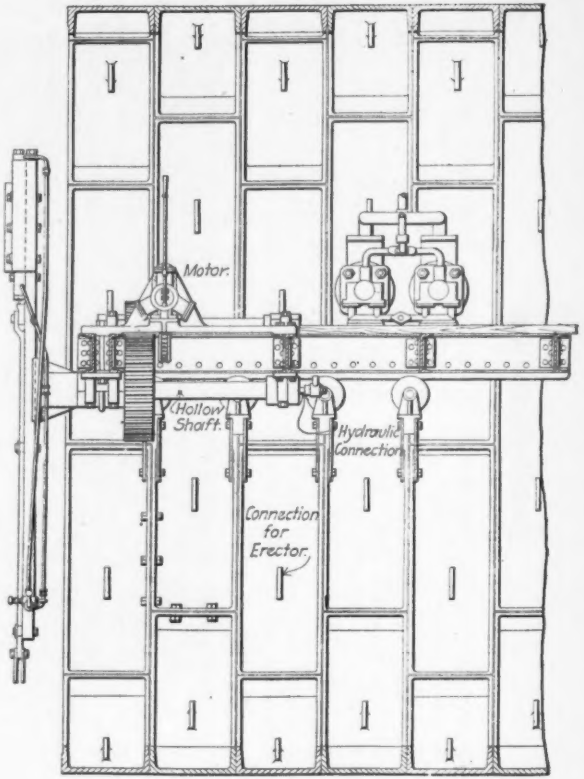
The working platform also has a removable forward extension of about 3½ feet, which is supported similarly by inclined shores. Both the upper and lower sets of shores are provided with connections for transverse horizontal beams on which poling boards can be driven in the face to subdivide it into five vertical sections, thus, in very bad ground, aiding to keep the excavation under better control, and, with a flat angle of slope, limiting the flow of soft material to short distances. The shield is equipped with fourteen hydraulic jacks set equidistantly around the outer rear edge and having pistons 8 inches in diameter with a 30-inch stroke. They were made by the Watson-Stillman Company, New York, and are operated under a maximum pressure of 6,000 pounds, which gives a total pressure of about 4,222,000 pounds available to advance the shield. The jacks engage the annular girder and react against the last ring of the assembled tunnel shell. They are supplied with hydraulic pressure furnished by a Watson-Stillman pump carried on the platform of the erector and operated by pneumatic pressure brought from the power plant on the surface to drive the tunnel machinery. The shield and fittings complete weigh 102,720 pounds. It requires nine men to operate each shield and excavate for it, and when all is in readiness it can be advanced 22 inches, the width of one ring of the tunnel shell, in 60 minutes. The best progress made by either of the four shields which have been installed is 4 feet in one eight-hour shift. The principal features of the shield which are considered novel by its designer are: the removable hood and platform, the inclined shores, beams and poling boards to support the working face, the absence of vertical protection in front of the working platform, the single opening in the center of the bulkhead, and the operation of the sliding doors and their control from outside the air lock, for all of which patents have been applied for.

The shields are each followed closely by an erector which assembles the segments of the tunnel shell and is of simple construction designed to be easily operated and to avoid obstructing the tunnel or interfering with the operation of the shield or the handling of spoil. It consists essentially of a traveling platform provided with an extensible radial arm pivoted in the tunnel axis and revolving at right angles to it. The platform is about 14½ feet wide and 10½ feet long with a framework of 10-inch channels. At each side a horizontal flat bar projects down so that its lower edge serves as a rail engaging four double flange rollers in bracket pedestals bolted to the tunnel lining. This arrangement permits the rollers to be moved from rear to front as the erector advances and successive rings of the tunnel shell are added, and provides for the support of the platform without jacking it up as would be necessary if the rails were fixed and the rollers attached to the platform.

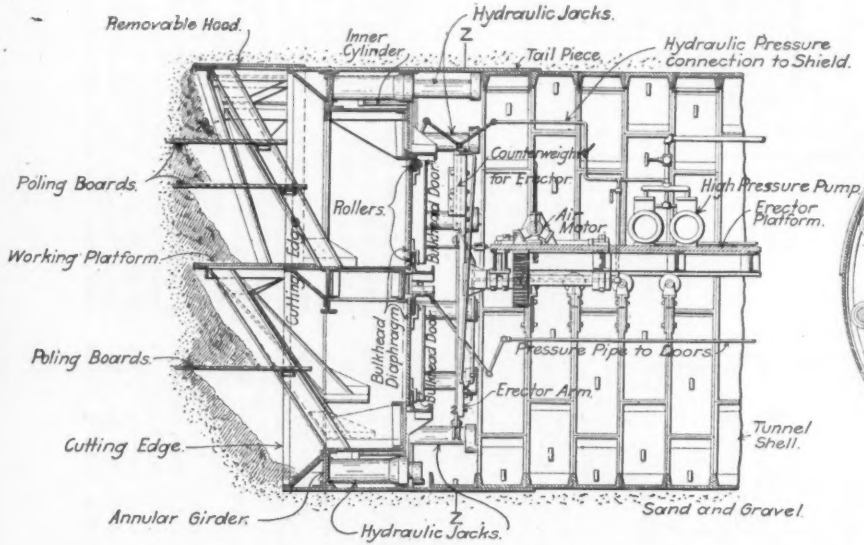
The radial arm has a 4 by 1 inch extension bar moving between guide rollers and fitted with jaws at the outer end which engage the erection lugs on the shell segments. At the opposite end it is connected to the 3-inch rod of an hydraulic piston 4¼ inches in diameter with a 24-inch stroke. The arm is mounted on a horizontal main shaft in the axis of the tunnel, which is driven with gear and pinion by an Ingersoll-Sergeant three-cylinder air motor on the platform. The end of the radial arm is connected to a shell segment on a car in the tunnel and the arm is then revolved by a man on the platform until the segment is in the required angular position, when the hydraulic piston is operated to extend the arm and carry the segment out to its place in the ring.

Water under pressure is delivered through the hollow main shaft to both ends of the cylinder, and as the piston is twice as large as the rod the pressure on the outer end of the cylinder is great enough to force out the segment and when it is released the constant pressure at the opposite end of the cylinder returns the piston to position for another segment. The waste water is discharged into the heading and thus only one connection is required and simplicity of operation is secured. A 1,000-pound pressure is used and the cylinder is operated from the extremity of the arm by the man who assembles the ring segments. Pressure is furnished by the pump which also operates the shield jacks and is driven by air at a pressure of 100 pounds. The erector and machinery weighs about 3 tons and requires a total force of four men to handle it and erect the lining segments. The short end of the erector arm is counterweighted so

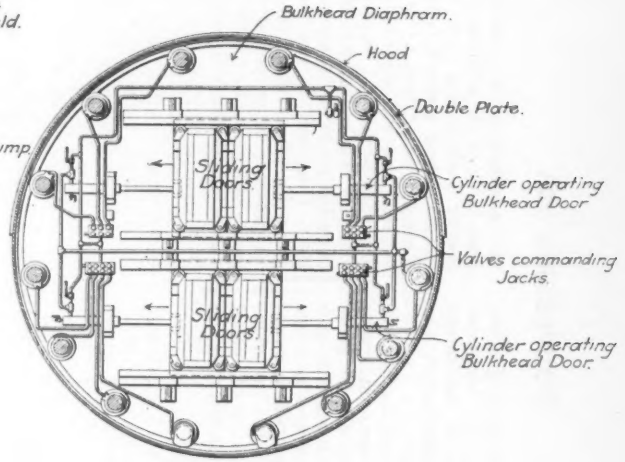




NEW YORK AND BROOKLYN TUNNEL: TRANSVERSE AND LONGITUDINAL SECTIONS SHOWING CAST-IRON SHELL AND ERECTOR, WITH PLATFORM.



Longitudinal Center Section.



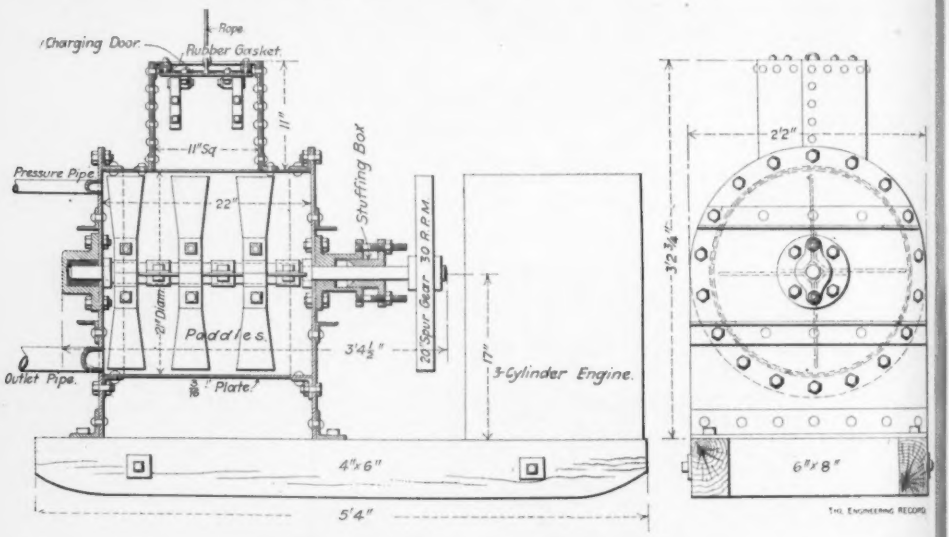
Sectional Elevation Z-Z
showing Fittings on Bulkhead Diaphragm

THE ENGINEERING RECORD.

FRONT OF SHIELD, GROUT MACHINE AND SECTIONS IN HEADING, SHOWING TUNNEL SHELL, ERECTOR AND SHIELD, WITH HOOD AND POLING BOARDS IN POSITION.

that with the cylinder it about half counterbalances the weight of the long end and a 900-pound segment of the tunnel shell. Applications for patents on this erector have also been made.

The erector is followed, as described in the previous article, by a grouting party which injects 1:1 Portland cement grout under pressure through holes left in each segment of the lining and closed by screw plugs. In each heading the grout is mixed by power in a closed steel box to which pressure can be admitted to force it through the shell against the exterior hydrostatic pressure to fill the interstices in the dry stone packing and thus form concrete filling in the space between the shell and the rock on the New York side and forming an enclosing sleeve several inches thick in the sand on the Brooklyn side. The grout machine used on the Brooklyn side has the dimensions shown in the accompanying engraving, but on the New York side is made 3 feet long instead of 22 inches. A shaft through the axis of the horizontal cylinder is driven through spur and pinion gears by an Ingersoll-Sergeant three-cylinder air engine. This shaft makes about 30 revolutions per minute and carries six double paddles which thoroughly mix the ingredients. On the upper side of the cylinder there is a small hopper with a flap door opening downwards. Three bags of Giant Portland cement and three bags of crusher dust are emptied into the hopper from the working platform above. A sufficient quantity of water is admitted and the hopper door is pulled up to set against the upper gasket. The shaft is revolved to mix the grout for about three minutes and then air pressure of 90 pounds is admitted to the cylinder and forces the grout through a 2-inch outlet in the bottom and a flexible hose connected with the 1¼-inch hole in the tunnel shell. The contents of the mixer are usually discharged in about 1½ minutes. A batch can be measured, mixed and injected, and the machine made ready for another in five minutes. Two hundred bags of cement were thus used in a single eight-hour shift by one gang which also has to move the machine, arrange the scaffolds and calk the joints. The hose generally used is 30 feet long, but it is sometimes extended; the machine is moved at least every 100 feet. Every plug in every plate is tried, but it is not always necessary to connect the hose to each one. The machine and its motor are



GROUT MIXING AND INJECTING MACHINE.

mounted on a solid wooden platform with rounded ends which is easily skidded along on the tunnel floor, and when in service is lifted up to a position just under the tunnel platform, close to the tunnel wall, where it affords little obstruction to the passageway. The working platform is made of loose planks laid across 4-inch horizontal pipes about 16 feet long which rest on the center flanges of the shell segments.

The shields and erectors were built by Alexander Miller & Brother, of Jersey City, and the grout machines were built by the Cockburn Barrow & Machine Company, Jersey City, all having been designed by Mr. Walton I. Aims, chief engineer of the New York Tunnel Company, which is the sub-contractor for the tunnel.—*Engineering Record.*

Causes of Explosions in Air Compressors.*

The following is a brief description of the conditions under which explosions have occurred recently on the Rand:

In one case there are two compressors working side by side, a horizontal twin tandem-compound steam and two-stage air (Walker), having 13 inch and 26 inch diameter (two each) steam cylinders and 24 inch and 38 inch diameter air cylinders, all 48-inch stroke, speed 25 revolutions per minute; and a horizontal cross-compound steam and two-stage air (Riedler), having 20 inch and 34 inch diameter steam cylinders, and 20 inch and 33 inch diameter air cylinders, all 48-inch stroke, speed 68 revolutions per minute. Each compressor is jacketed and has inter-cooler, and delivers air to a common receiver.

At 5.30 P. M. on Saturday, September 26, 1903, while both compressors are running full, the driver sees a flame burst from the high pressure air-delivery pipe connecting the heads on the Riedler; this is followed by dense smoke. Both engines are stopped as quickly as possible, and on examination it is found that the T-branch leading away from the cylinder is cracked right round, practically broken off. The packing is blown out of the joints, and general signs of burning are visible. A lot of deposit is found in the valve-chambers and cleared away. No smoke is reported as being delivered to the drills in the mine. This may be accounted for by the fact that on starting up again after repairs it is found that a valve on the air-main or shaft is chocked with the same deposit. Temperatures of the air, etc., at the time are not available, but immediately on resuming running, and when under the same conditions, a temperature of 325 degrees is found in the high-pressure delivery, with air pressure of 75 pounds. The cooling water is not obtainable under 118 degrees F. The usual lubrication of cylinder up to the time of explosion is a mixture of one part of valvoline oil to nine parts of soapy water, which is perfectly satisfactory, judging by the condition of bore of cylinder and of the valves. The air intake is, as usual, an opening on valve-chest, protected by coarse wire netting. The Bristol recorder has made no indication of any excess of pressure at the moment.

In another case there are three independent compressors working together, serving into one main leading to a receiver from whence the supply goes to the shaft. The sizes of the compressors are:

1. Vertical (King-Riedler) 19 inch and 30 inch diameter steam cylinders, 20 inch and 32 inch air cylinders, all 42-inch stroke, speed 80 revolutions per minute.

2. Vertical triple-steam and two-stage air (Vulcan) with 14.5 inch, 23.625 inch, and 35.5 inch diameter steam cylinders, and 18 inch, 23 inch, and 23 inch diameter air cylinders, all 35.5-inch stroke.

3. Horizontal cross-compound (Ingersoll-Sergeant) with 18 inch and 34 inch diameter steam cylinders, and 18.25 inch and 30 inch diameter air cylinders.

All the air cylinders are water jacketed. The relative position of the compressors is such that the delivery pipes form a T, with the King-Riedler and Ingersoll at either end of the top member, and the Vulcan between them close to the branch which leads to the receiver just outside the engine-house. There are two safety valves on the air-pipe, one close to the King-Riedler and one close to the Vulcan, as well as one on the receiver outside.

At 1 A. M. on November 24, while all three compressors are working at ordinary full speed against a gauge pressure of 68 pounds, the driver, who is standing by the King-Riedler, sees flames burst

* Abstract of paper by E. Goffe from *The Journal* of the Mechanical Engineers' Association of the Witwatersrand, February, 1904. Abstract and illustration reprinted through the courtesy of the *Engineering and Mining Journal.*

from both safety-valves, extending up to the roof, this being followed by dense smoke, which fills the whole place. A similar flame comes from the safety-valve on the receiver. He immediately slows down the engines, and no further development occurs. The Bristol recording gauge shows a sudden and momentary rise of pressure to 120 pounds. The resulting out, and a charred residue is found afterward in the valve-chambers. A sample of this deposit is now being analyzed.

Smoke is reported as having been delivered to the machines in the mine. There are no marks and no evidence of the flame having struck back to either the Vulcan or Ingersoll compressors.

The oil used on these compressors is

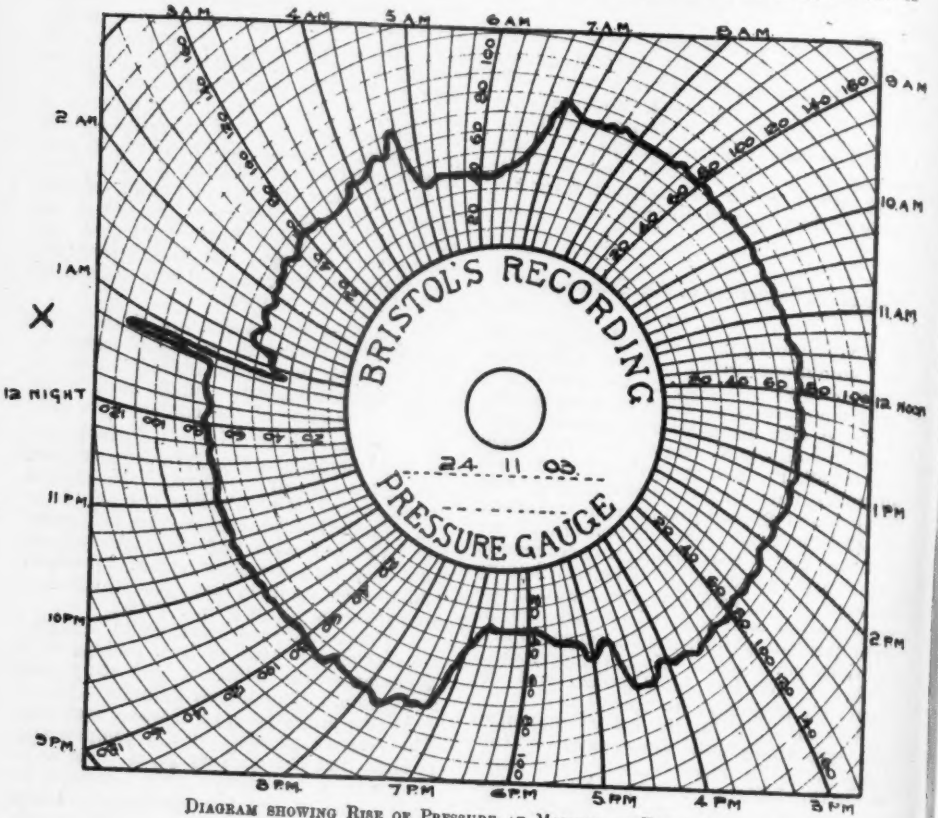


DIAGRAM SHOWING RISE OF PRESSURE AT MOMENT OF EXPLOSION.
X Pressure due to Explosion

damage is found to be that all paint and grease are burnt off the outside of the delivery pipe from the King-Riedler to the branch of the Vulcan, thence along to the receiver. The outside of the receiver is burnt in a similar manner, and the mine pipe as far as the collar of the shaft. All the soft packing on the valve-stems of the air cylinders of the King-Riedler is burnt high-grade, with a flash-point of 494 degrees F. The quantity used by the three, that is for air cylinders alone, is one gallon per 24 hours. The method of oiling the King-Riedler air cylinders is with a pump lubricator, having leads to each valve-stem, etc. The driver, on coming on shift, opens each cock on the various oil-leads in turn, and gives two or three

strokes of the pump, feeding probably as many ounces of oil at a time which has to serve for some hours. There are sight-feed lubricators also fitted to the covers. No soft soap or soapy water is ever used. The valves are taken out and examined regularly fortnightly, and forks adjusted.

The temperatures of the air at the time of the explosion are not known, but from observations taken by me during several weeks immediately after, at times of greatest output, the maximum observed was 290 degrees F. in the high-pressure delivery, with 264 degrees F. in the low-pressure delivery, both taken close to the delivery-valves.

The first-stage air, by passing through the inter-cooler, is cooled down to between 80 degrees and 90 degrees F. The jacket water is ample and always cold, the difference between the inlet and outlet being only just sensible to the touch. The air intake to the King-Riedler is entirely from the engine-room, is fairly high up, and ranges in temperature from 90 degrees F. to 102 degrees F.

I have knowledge of three other explosions which took place earlier in the year at other mines. The conditions and experiences are similar, and all happened with two-stage compressors. The oil used in one case was submitted to me for testing, and the flash-point was found at 550 degrees F. (open flash).

Now, it is evident that there must be two factors before an explosion or flashing can take place; first, an explosive mixture; second, a temperature sufficiently high to explode this mixture. To account for the formation of an explosive mixture, the oil used is usually the first thing blamed. If an ordinary lubricating mixture is in use this may be justifiable, but so much depends on the conditions under which the compressor is run. I have in mind one compressor, close at hand, in which the engineer uses ordinary good engine oil, in quantities not exceeding two drops per minute per cylinder, and has never had the least trouble with it; the valves keep perfectly clean and never stick. But that compressor is a slow running one, about 40 revolutions, is amply large for its work, works only 10 hours per day, has good cooling water, and delivers its air to the receiver at abouf 120 degrees F. Air pressure is 70 pounds. The writer has not tested the temperatures close to the delivery valves, but it is evident from inspection of the valves that there is no trace of decomposition of the oil on them.

In the case previously mentioned of a compressor using a high-grade oil with flash-point of 494 degrees F., and in which the highest observed temperature of the air was 290 degrees F., there would appear to be an ample margin of safety unless the decomposition of oil takes place much more readily under pressure, which, if not already proved, should be easily demonstrated by a laboratory experiment. It is always possible, of course, for a careless driver to use an inferior oil, or even a dose of paraffin in the air cylinder, but it is possible to guard against that by having only the one oil accessible to him while on the engine.

A small proportion of foreign oil, together with other matter, might find its way into the air cylinder by means of the piston rod. Many air cylinders are arranged tandem, with the steam cylinder using the same rod, which, for part of its length, is alternately in each cylinder.

As usually arranged, an air compressor is an excellent dust trap, with its open inlets, frequently opposite an open door through which comes all its air, laden with dust, a good proportion of which will be probably coal dust, the boiler-house and coal bunkers naturally being near by. The coarse wire screens prevent ordinary portable articles going into the valve-chamber, but that is all. In the recess of the valve-chambers, ports, air-pipes, inter-cooler, and receiver, this dust will accumulate, making with the oil a pasty, gummy mass, which will stick fast. In one case here this mass had accumulated about the valve on the air main from receiver, and the air could never be delivered to the mine within about 20 pounds of the gauge-pressure at compressor, and it was not until an explosion occurred and the pipe system had to be overhauled that the reason for the constant difference in pressure was found. Now they get air in that mine.

It is probable that even a high-grade oil, mixed up with coal dust and foreign matter, including metallic particles, and exposed to a temperature considerably below its original flash-point, under pressure for months or years, will arrive at a decomposing point and produce an explosive gas or other mixture. Then, given favorable conditions otherwise, a hot in-

take, failure of cooling water, etc., an explosion will probably occur.

Considering now the second condition for starting an explosion—the temperature attained—it has been well shown by some calculations made by Mr. Hill, of Norwalk, Conn., that leaks through the pistons and valves of air cylinders are able to produce much higher—in fact, dangerously higher—temperatures than can be calculated upon in the ordinary way, and in single-stage compressors well overlapping the flash-points of many oils. In two-stage compressors this danger is much reduced, but still much higher pressures than normal may be reached. The effect of these leaks on ultimate temperature is, naturally, the same as of a high temperature of the intake, or of an inefficient inter-cooler, and the starting temperatures being known the resulting temperatures are calculable in the usual way.

It would be interesting to know whether the calculated temperatures of compression are all that are reached to, or whether under some conditions pressures are reached in cylinders higher than any that are expected. The usual method of thermometer tubes in the air-pipes gives a sufficiently accurate reading of the temperature of the air passing through, but ordinary thermometers would not show the varying temperature conditions in the cylinders. What would be required for that would be an extremely sensitive instrument which would register every variation instantly, and record it.

After examining the conditions under which those explosions in air compressors have taken place which have been brought to my notice, I conclude, therefore, that the principal cause is the presence of accumulated dust in the interior of the valve-chambers, pipes, and receivers. This dust absorbs the excess of oil, and the resulting mixture decomposing will give off explosive gases, which, on the occurrence of favorable circumstances, will be ignited, probably by the glowing of some of the more easily combustible portions of the dust.

A Power Accumulator.

To utilize the vast natural powers of wind and tide, Samuel A. Donnelly, of Chicago, has invented a device whereby he claims this heretofore wasted energy may be controlled and accumulated ready for use as desired. He has selected compressed air as the most suitable medium for power transmission and storage. Mr. Donnelly's invention, which is shown in the accompanying illustration, is intended to be operated by a windmill, a wheel driven by a current of water or a wave motor. It is designed to gather up these irregular and unsteady forces and automatically adjust them to an even duty.

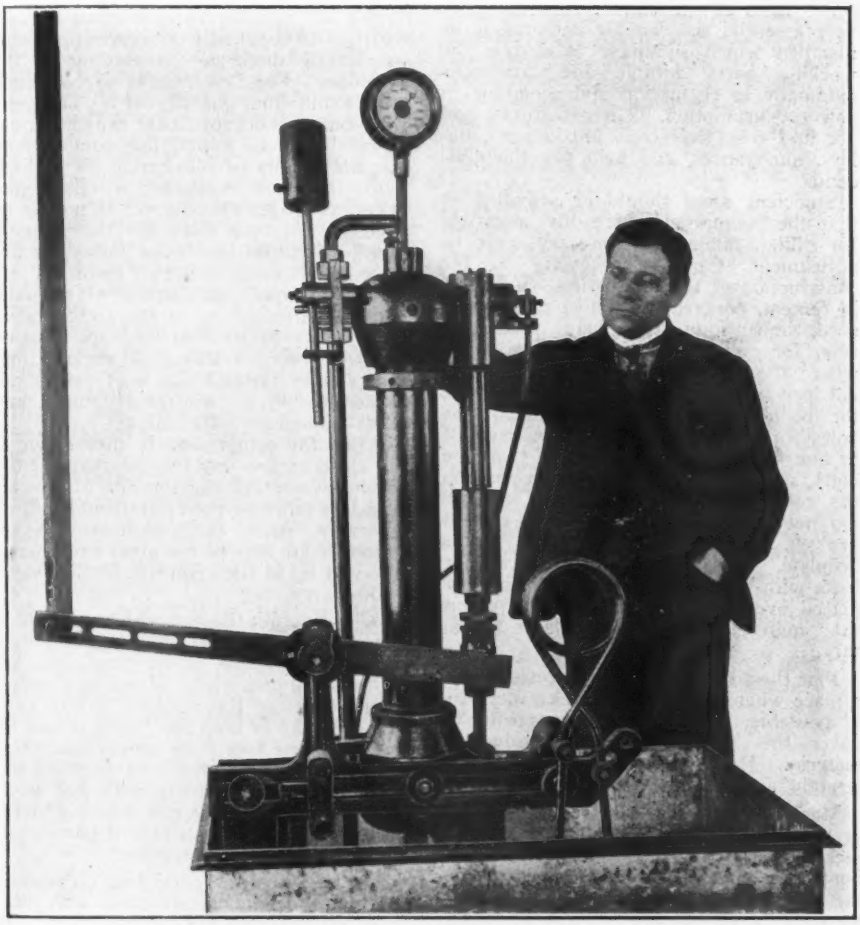
Three fundamental principles are combined in the accumulator, a lever, a hydraulic pump and an air compressor. The method of combination is unusual and is so different from all previous ones that basic patents have been granted to Mr. Donnelly. What might be termed the most unusual feature of the device is an adjustable fulcrum for the lever. It is intended to adapt the irregular forces exerted to a constant and even load.

As will be seen in the illustration, the power is applied to one end of the lever through a rod, as seen on the left hand side of the illustration, coming from the windmill, current or wave motor, or whatever is used. The other end operates the piston of a simple hydraulic pump, in which is a mixture of water and glycerine. The object of the glycerine is to lubricate the cylinders through which the liquid is forced, to keep the water from freezing in cold weather and to assist in cooling the air as it is compressed. From the pump, which is shown on the right of the machine, the liquid is forced into the central tube or compression chamber, where it becomes the piston of the air compressor. This liquid piston is operated very slowly. Slow compression, combined with the cooling qualities of the liquid, result, the inventor claims, in keeping the heat of compression at a very low point and in eliminating some of the loss which the heat causes in the common type of air compressors. Using a steel tube 36 inches long by 4 inches in diameter as a compression chamber, Mr. Donnelly has secured air at a pressure of 15,000 pounds to the square inch. With a long tube, he predicts that there will be no trouble in increasing the pressure from 3,000 to 4,000 pounds.

We are indebted to Mr. Donnelly for this description and illustration of his accumulator, but he has not revealed the secret of the adjustability of the fulcrum.

Mr. Donnelly's invention can be oper-

ated in several ways, but the inventor has devoted most of his attention to its use in connection with the windmill. As standards to support a windmill, he suggests hollow steel tubes, which may be used as storage tanks for compressed air.



POWER ACCUMULATOR.

It is his intention that the accumulator shall operate whenever power is supplied and that the air compressed by it be stored for use as may be wished. While the accumulator does not compress air very rapidly, he anticipates that its almost constant service will meet nearly any requirement. When operated by the winds its installation will be practical at any point.

The uses of compressed air are so varied that Mr. Donnelly expects tl is invention will give many modern conveniences to those who have heretofore lacked means to supply them. Another argument which he uses in favor of the general adaption of his accumulator is that, if built in large quantities, its cost will not amount to more than several hundred dollars.

Compressed Air Installations.*

The air compressor is the most important feature of a compressed air installation, inasmuch as the successful and economic operation of the entire plant depends upon this machine. It is therefore very essential that an air compressor be installed which is simple in design, the working parts durable and accessible, automatic in regulation and economic in power consumption. These features, and not first cost, save coal, breakdowns, delays, annoyances, and help pay the dividends.

Sufficient room should be provided so that the compressor is readily accessible for oiling, taking up necessary wear or adjustment. Care is necessary in the construction of the foundation. Brick set in cement, concrete or timber are largely used, timber foundations being used, as a rule, for only small air compressors, or where the location of the compressor is not permanent. Exercise care to insure the bedplate being perfectly level. The holes for anchor bolts should be one-half to one inch greater in diameter than the bolts, and after the bedplate is in position the remaining space filled with cement. Do not bolt bedplate down until cement has set, so as to avoid springing of the bedplate. It is recommended that anchor bolts with keys be used and an iron plate placed over the keys, arranged to permit the removal of keys and bolts if necessary.

Pipe the air inlet of the compressor from a place where the coolest and cleanest air is available. It is often advantageous to cover this piping with non-conducting material. Have the air discharge pipe as straight as possible.

Machines intended for pressures above 25 pounds per square inch have water-jacketed air cylinders, through which cooling water in sufficient quantities to keep the cylinders cool should be circulated all the time the compressor is running. When shut down, drain the water jackets in cold climates to avoid freezing.

Before starting every working part must be carefully examined and made free from all grit and dirt. If the compressor be steam-actuated, it is advisable to blow steam all through the pipes (the air-inlet pipe as well) before the compressor is connected and operated.

The journals require that they be carefully examined and not keyed up too tightly, but never, under any circumstances, allowed to become loose enough to pound.

The air cylinders are lubricated internally by oil supplied from lubricators communicating direct to the interior of the cylinders. The best results are obtained with a minimum quantity of oil, as otherwise oil will occupy space which should be filled with air undergoing compression. A good quality of lubricating oil of high flash, free from residuum, will be found suitable. Steam-cylinder oil is not to be used, as it is too thick for the purpose. Many difficulties have been caused by improper lubrication of the air cylinders.

An occasional examination of the inlet and discharge valves of the air cylinders is necessary to see that they are in good working order. A leakage of air back into the cylinder through the inlet valves can be detected by a "wheezing" sound, and needs immediate adjustment.

When the compressor is shut down at the close of the day the oil supply from the lubricators to the interior of the air cylinders must be promptly turned off, as otherwise, when the compressor is restarted, there may be too great an accumulation of oil in the cylinders for the valve to discharge.

Do not permit the compressor to remain unused for a considerable length of time without the pistons, piston rings, etc., being removed and oiled. If not in constant service, operate the machine a few minutes each day to keep the cylinders and all working parts free from accumulations of any kind. A good plan is to wash out the air cylinders occasionally with hot soapsuds, so as to remove all accumulations. Use extra heavy double belt of good quality to drive belt compressors.

For air pressures exceeding 60 pounds per square inch, air compressors with compound air cylinders are recommended. The benefits derived are cooler intake air, dryer discharge air, better lubrication, reduction of clearances and heat losses, lower working strains and more uniform resistance, resulting in a higher efficiency with a saving of power consumption. The life of the compressor is also increased. Like all mechanism, air compressors require careful attention. Proper care at the proper

*Written by Fred. B. Vail for the *Manufacturers Record*. Baltimore, Md.

time will save many annoying delays and expense.

The air receiver can be located as best suits individual requirements. There should be a factor of strength at least from 50 to 100 per cent. over the maximum air pressure to be carried. It is equipped with pressure gauge, safety valve, drain cock, and on larger sizes a manhole. The receiver is used as the means of eliminating the pulsations of the air as it comes from the air compressor. It also eliminates a certain amount of moisture. This moisture can be drained off by means of a drain cock located near the bottom of the receiver.

Blow out the air receiver and the air-discharge piping thoroughly with air each morning before starting up the plant, and as more often as necessary, thus forcing out any accumulations of oil or condensed moisture.

A second and smaller air receiver is often used, this being located near the place where the compressed air is used. The air enters at the top and discharges at the bottom. The object of this tank is to deflect the air, thus removing the moisture.

Use air-discharge piping of proper size, and have the general design so as to avoid as many sharp turns or elbows as possible. If the piping is of sufficient diameter frictional losses will be very slight.

Remedy all leaks immediately. For instance, at 100 pounds air pressure through a ⅛-inch opening 25 8-10 cubic feet of free air will flow per minute, which means a loss of nearly 5 horse-power. It is therefore important that leaky valves, pipe or hose be repaired or replaced at once.

Air reheaters are used to great advantage. Atmospheric air is never dry, containing a certain amount of moisture, according to varying conditions. Where air is used expansively this moisture must be eliminated, or the air reheated, to prevent freezing and choking of exhaust ports. Place the reheater as near as possible to the point where the air is to be used, and the outlet pipes should be short and well covered. A reheater will increase the efficiency of the air plant.

The rock drill has revolutionized tunneling, mining and quarrying methods, and has become such an important factor that various manufacturers treat this subject by itself, and therefore issue catalogs regarding general construction, types and styles for various classes of work and considerable data in regard to their operation and care. These devices are built for rough usage and considerable exposure, but this does not mean that they do not require inspection and care. The mounting of a rock drill should be firmly secured. Blow out the hose before connecting it to the drill. Where compressed air is used the drill will start at once, but with steam it requires a few minutes for the machine to become equally heated. Start the drill slowly and on a short stroke until the hole is about 4 or 5 inches deep, at which time the drill can be run at full capacity.

Do not use a heavy grade of oil when operating with air, as such oil freezes readily or thickens and retards the drill. A good grade of zero black oil is recommended. All bolts and nuts should be carefully looked after and properly tightened. Careful attention to these features will not only increase the life of the drill, but will prevent breakdowns and delays.

Too much attention cannot be paid to the thorough and systematic cleaning of all pneumatic tools, and no other class of machinery will show larger results for care thus bestowed. These tools are necessarily of a very high grade of workmanship, and while they are built for hard, rough work, they should receive the best of care in order to keep them in good working order. Particularly is this true of pneumatic tools used in foundries and stoneyards, where they are subjected to the cutting action of sand and dirt. In all kinds of work where chipping and riveting hammers are in constant use they should be taken apart, soaked in benzine and thoroughly "blown out" with air pressure once a day. Be sure that all the holes and ports in the valve and cylinder are free from scale or dirt. In many shops the hammers are allowed to stand over night handle-end down in coal oil. They are then dipped in benzine, "blown out" and oiled. Always oil tools thoroughly after using coal oil or benzine. This keeps them in good working condition.

Inspect surfacing machine at least once daily. All bolts and nuts are to be properly tightened and the tool thoroughly cleaned as occasion may demand. Treat plug and feather tools exactly the same as chipping hammers.

Clean air drills with coal oil or benzine, pouring same in through the handles as

well as through the oil cock, and blowing all the parts out thoroughly with air pressure. Taking the drill apart once a week and thoroughly cleaning all parts will result in longer life and better service. In reassembling the drill care must be taken to have all screws and nuts drawn up tight. Ball bearings must be carefully adjusted and locked with locknuts provided for the purpose.

In a general way, directions for cleaning chipping hammers must be followed in the case of foundry rammers.

Oil yoke riveters once an hour by detaching the hose and oiling through the air inlet. Occasionally oil the sliding cylinder, also the inside of the nosepiece around the button-set shank, as in the case of riveting hammers.

Treat motor air hoists exactly the same as air drills. Inspect cylinder air hoists from time to time. Oil properly the air valves and keep them clean. It is also of utmost importance to keep the stuffing boxes tight.

All pneumatic tools when in use, except air hoists, should be oiled once every hour with good light oil. There are a number of brands of special pneumatic-tool oil on the market, and this is to be used to get the best results. Never use heavy oil. The expansion of the air when passing through the tool lowers the temperature and causes ordinary oil to become thick and gummy. This interferes with the free movement of the parts, besides clogging up the small air ports. Owing to the incessant vibration of air hammers, they are not provided with an oiling device, but drills, motor hoists and other pneumatic tools are usually provided with a device for this purpose.

There are several brands of grease offered on the market, all of which are highly recommended. This grease is specially recommended for the lubrication of pneumatic tools, inasmuch as when it is put into a drill or hammer, instead of blowing out instantly like oil, it will stay in, lubricating it for hours.

It is very essential that the chisels be kept in proper condition. The heads or shanks of the chisel should fit the tool properly, and heads must be ground perfectly level, otherwise the piston will break or crumble on the ends. In cases where a chisel bushing is worn, allowing the chisel too much play, the bushing needs renewing, so that the chisel cannot assume an angular position and cause the breaking of the hammer. In most all shops and yards this work is put in charge of a capable blacksmith. Failure to obtain proper results is often blamed upon the tool, and the whole fault lies with the chisel.

Some pneumatic tools are provided with an air strainer. Frequent complaints are received from new customers that the tool "has lost its power." In almost every case this is due to the air strainer becoming clogged with dirt from the hose and air pipes, thus preventing the free passage of the air to the tool. It is a simple matter to remove the air strainer and blow it backward with air pressure. This will remove all dirt, and the tool will be found to work all right. No pneumatic tool should ever be used without an air strainer.

It is important that the handles of chipping hammers and plug drills be screwed down hard on cylinder at all times and held there by the clamping device. If allowed to work loose the joint between the valve box and the cylinder end will be destroyed, and the tool will not only refuse to work, but great injury will be done to the whole mechanism. A little attention paid to this simple requirement will save a lot of trouble.

Air hose, as before explained, must be kept tight. There have been many occasions where customers have complained of not obtaining sufficient air from the air compressor, when, through carelessness and inattention to leaks, more air has been wasted than is required to operate all the tools. This hose should be of durable quality and strength for maximum pressures. Care must be taken not to overfeed the air cylinders of the compressor with oil, as this will pass through the piping and disintegrate the hose.

A self-closing hose-coupling and automatic stop-valve cannot be too highly recommended to users of compressed air where several hundred feet of hose are connected together with only one stop-valve located at a long distance from where the pneumatic device or tool is in operation. The air is immediately shut off when this coupling is disconnected, and in disconnecting it both the machine and the host can remain stationary, as the valve also is a universal joint. In selecting a coupling of this kind, be very

careful to purchase one which is absolutely airtight, durable and efficient.

Large users of pneumatic tools always place the entire compressed-air plant in charge of one man, whose duty it is to look after all of the various devices. In medium and small plants some reliable employee should be assigned and instructed for this work as part of his duty, and held responsible. Cleanliness is a necessity. A proper record of all the compressors and tools should be carefully kept, so as to give the manufacturer any and all information in order that he may make any suggestions or repairs. Remember that the entire success of a compressed-air plant entirely depends upon proper care. Do not blame the manufacturer for your own carelessness and neglect.

Economy in Compressed Air Mining Plants.*

Members of the California Miners' Association—After accepting your Secretary's invitation to read a paper on compressed air, it occurred to me that you are all familiar with the fact that compressed air is a useful and necessary adjunct to most mining operations, and that you are also well informed regarding the methods of compressing air by motors driven by steam, water or electrical power, and that you are equally well acquainted with the uses for compressed air about a mine, and with the various machines that can be driven by it. Therefore, it would not be as interesting to you to review these subjects as it would to speak of how the making and the use of compressed air may be bettered both in the work it does and the cost to compress it.

No subject connected with the operation of a mine has more interest to the miner than that of cheap power, and considerable finesse is exhibited in procuring a low rate per horse-power and being contented with that.

There is, however, another and more important feature which is too frequently overlooked, viz.: The amount of power which is used in mining operations. It is just as economical and important to effect a reduction of 25 per cent. in the amount of power used as to effect the same reduction in the rate. The power required to operate the compressed air plant about a mine is a considerable item, being from 25 to 50 per cent. of the total power used, and it is safe to say that of this, from 25 to 50 per cent. could be saved in very many plants with but comparatively small expenditure.

It will be the purpose of this paper to indicate how this may be accomplished in a perfectly practical way, assuming that the kind of power already installed is the most feasible.

With any given compressor, there is a saving to be made of from 5 to 10 per cent. in favor of driving direct by a water wheel or steam engine, rather than by means of gear or belt. But this is not always practical or feasible. A great saving may be made in the ordinary steam-driven compressor as far as the motor end is concerned. The engines of steam-driven compressors are ordinarily equipped with either plain slide valves, Meyers cut-off gearing, or compound cylinders.

The plain slide valve engine consumes from 45 to 50 pounds of steam per horse-power hour. The steam consumption is large because the mean effective pressure required to do the work being low, the steam is throttled at the governor, or shut-off valve, and introduced into the steam cylinder at low pressure, thus giving no benefit from the high steam pressure or expansion.

The Meyers cut-off, however, does away with much of this loss and gives the steam a chance to work expansively, and the steam consumption will probably be from 35 to 40 pounds per horse-power hour.

With the compound engine, the steam consumption will be from 30 to 35 pounds per horse-power hour. Condensing engines would give larger economy, but for the average mining plants would not be desirable. I am speaking always of only such mechanisms as are simple and perfectly easy to understand and to operate, and I have given very practical values to the steam consumption.

Taking these figures, it will be noted that the Meyers cut-off is at least 20 per cent. more economical than the plain slide valve, and the compound cylinders are 30

* By Edward A. Rix, E. M., in the Proceedings of the Twelfth Annual Convention (1903) of the California Miners' Association.

per cent. more economical. For example, a three-drill compressor—12 x 12 x 12:

The plain slide valve will cost.....$1,300
The Meyers cut-off will cost..... 1,350
The compound cylinder compressor will cost 1,650

This is a 50 horse-power compressor, and if a horse-power should cost but $5 monthly, the Meyers cut-off would pay for its extra cost in a month and the compound in five months, after which there would be a clean saving of $50 to $75 monthly, an item not to be overlooked.

Now, I estimate that there are in California, of the steam-driven compressors, about 85 per cent. of the plain slide valve class, about 10 per cent. of the Meyers cut-off class, including Corliss driven compressors, and about 5 per cent. of the compound class. The loss, therefore, must amount to a very large sum yearly.

Owing to the fact that the price of the economical machines is within reach of everyone, there should not be a single plain slide valve compressor used in a mining plant, and particularly should this be true for a prospecting plant, where every dollar saved on top and put into the development means an added chance for success.

Coming now to the air end of the compressor, it has been quite well demonstrated that a two-stage compressor for pressures above 60 or 70 pounds is very much more desirable and economical than a single stage machine.

In the first place: It requires from 10 to 15 per cent. less power to compress 90 or 100 pounds by a two-stage machine.

Secondly: The temperature created by compression is only about one-half, that is to say, from 200° to 250° Fahrenheit in the cylinder, instead of from 350° to 450°. The lower temperature permits better lubrication and wear in the cylinder and does away with the danger of cylinder or receiver explosions due to the ignition of the gases given off by the lubricants.

In the third place: It gives a proper capacity of air delivered for the size of the air cylinder. Right here is a point which should appeal to every one.

All compressor catalogs give the rated capacity of a compressor in cubic feet of piston displacement, at a certain speed, and too frequently purchasers believe that these figures indicate the free air capacity. If they buy a machine having one hundred cubic feet displacement at 150 revolutions per minute, the supposition is that the compressor will deliver about that quantity. This may be nearly true of a two-stage compressor, but not for a single-stage machine. The single-stage machine is generally equipped with poppet valves, and the considerations of speed, valve clearance, piston clearance, piston leakage, valve leakage, temperatures, valve inertia, springs, tensions and atmospheric temperature, all tend to reduce this displacement figure, until the average poppet valve single-stage machine does not give over 75 per cent. of its theoretical volume at normal speed, and may drop to from 50 to 60 per cent. This means that while the machine is built for and is amply strong enough to give 100 per cent., it is not permitted to deliver its full volume by reason of facts set forth. The purchaser finds he cannot get air enough for his work.

The two-stage machine will give from 85 to 90 per cent. of its theoretical displacement, and with this machine the purchaser is therefore getting more for his money, buying the same cylinder dimensions as in the single-stage machine.

A single-stage straight line machine, 12 and 12 x 12 inches, will cost $800. A two-stage, 12 and 7 and 12 x 12 inches, will cost $980. Inasmuch as the two-stage machine will give 15 per cent. more air, the comparative price of the single-stage machine would be figured at $920. Consequently, the difference in price is $60, and because the two-stage machine is more economical to operate by 15 per cent., this small difference in price will be saved in two or three months. I estimate there are about 85 per cent. single-stage machines and about 15 per cent. two-stage machines in this State, showing that we have much to gain in economical working.

To conclude, then, as far as the compressor end is concerned, there are the following gains to be made, counting that the compressor is running at capacity ratings as to speed and pressure:

In power required, for a two-stage compound steam-driven machine over a single-stage plain slide valve, a gain of at least 50 per cent.

In volume, a gain of 15 to 25 per cent.

In cost, an insignificant increase compared to the saving.

In power actuated compressors, the corresponding gain would be a saving of

about 15 per cent. in power and a gain in volume of from 15 to 25 per cent. A 12 x 12 inches belt-driven single-stage compressor will cost $660, and a two-stage 12 and 7 x 12 inches will cost $860. Allowing for the difference in volume delivered, the comparison will be as $760 is to $860, a difference of $100, which will be saved in power in three months.

For altitudes, the gain in using a two-stage compressor is still more marked.

The next loss we meet with is in the pipe lines, where insufficient sizes cause a frictional loss of pressure and leaks cause a loss of volume. The latter is generally the greater. Tests of a great many pipe lines in mines develop the fact that probably none are tight and the majority leak from 10 to 30 per cent. Small leaks at each joint, which can only be discovered by using soap and water, make a considerable total loss.

For example, upon installing a large compressor under guarantee, at a well-known mine, a test was made for leakage. The pipe lines were long and numerous, having accumulated during ten years' working, and the mine manager was willing to allow but 5 per cent. loss for leakage. The pipes were sealed at all terminals and valves, and the compressor speed regulated so that it would hold the pipe line at exactly 90 pounds. It required 40 per cent. of the maximum revolutions of the compressor to hold the pressure. It was a surprise to every one. After a week's work on the lines the loss was reduced to about 12 per cent. and there remained. It is doubtful if the average pipe lines lose less than 15 per cent.

It is a very simple matter to determine and easy to remedy while installing the pipe. The loss should not be allowed to exceed 5 per cent. if economy is desired, and a line may with care be made practically tight. It seems a simple job to screw pipe together so it will not leak, yet it is not so, for it requires patience and experience. Plumbers encounter great difficulties in piping large buildings, yet their work must not leak, and the same degree of attention will give the same result for a mine and it will pay well to have it done properly from the very start.

The next source of loss is in using pipes that are too small. The temptation to use small pipes in levels and stopes is great because they can be put in place so readily. But they occasion great loss. It is impossible in this short paper to go into this subject. I might say, however, that, in many instances, pressure gauges placed on the drill hose have given readings of from 45 to 60 pounds, with from 80 to 90 pounds at the compressor.

It must be remembered that a drop of pressure of 10 pounds, from 90 to 80, for example, does not mean a 10 per cent. power loss—the loss is but 4 per cent.—but the loss in the work performed by the drill more than makes up for it. It would probably not be amiss to state here that the average pipe lines could be bettered at least 10 per cent. by stopping and using proper size of pipes.

It seems to be quite well understood at present that hoisting engines operated by compressed air should have the air reheated before use, and many have introduced either dry air heaters or steam heaters for their hoists.

In a hoisting engine, it takes about 25 cubic feet of free air compressed to 90 pounds to give a horse-power used cold, and about 16 cubic feet, or a saving of 35 per cent., when properly heated.

If compound engines be used on the hoist, and the air be heated to about 400° before using in each cylinder, a horse-power can be produced readily with 8 cubic feet of free air per horse-power, or two-thirds less than in an ordinary hoisting engine.

Where a good-sized hoist is used, the loss in using primitive methods runs into money very fast. As an example of how insignificant things cause losses in compressed air machines, my attention was called recently to a mill engine, driven by compressed air, that failed to give the stamps the requisite drops because the air supply was insufficient, although the air was reheated. Upon examining the engine, it was found to have an unusual clearance, and a three-eighths plate fastened on each face of the piston reduced the loss so that it performed the work in a most satisfactory manner. There are many engines running with similar losses in the mines to-day.

Compressed air hoists on the surface, and particularly under ground, should have sufficient receiver capacity attached, so that when the hoists are working they do not reduce the pipe line pressure too much, otherwise the work of the rock drills will fall off materially, but the machine men's wages are going on just the same.

The greatest loss in connection with

the use of compressed air in mines is in using the ordinary direct acting pump for station work, and but little progress has been made toward bettering this condition in any but two or three larger mines. The facts are these:

At 90 pounds air pressure, if it takes 100 cubic feet of free air to do a certain amount of pumping, using an ordinary direct acting pump, then 75 cubic feet will do the same work if the air be heated to 300°. Sixty cubic feet will be required in a compound direct acting pump where the heating is only enough to keep the pump from freezing. Fifty cubic feet will be required if heating be done to 300° before using in the high-pressure cylinder. Forty cubic feet only will be required if heating be done to 300° before using in the low-pressure cylinder also. Thirty-five cubic feet will be required for the work in a triple cylinder pump.

In other words, it is possible to save two-thirds of the air. It is not much trouble to do this heating underground, and the saving is enormous. Distillate at 5 cents per gallon can be used for heating. It is not dangerous, the odor amounts to nothing in a well-ventilated mine. Where any quantity of water is to be pumped, a small flue pipe can be run in one corner of a shaft compartment. This economical style of pumping is in constant and satisfactory use at the North Star Mines on their lowest levels.

Compressed air may be used in pumping in such a manner that its commercial economy may more than offset its mechanical economy. Commercial economy has for its basis the total cost to accomplish an end rather than the cost at any unit of time. For example, last year the Brunswick Mine at Grass Valley struck a flow of water on the 1,250-foot level that the Cornish pump could not handle, and the mine filled to the 700-foot level, at which point the Cornish pump held the water. The problem was to recover the 1,250-foot level and establish a station pump there. It is evident that if there was no water flowing into the mine, the most economical way to remove it would be to apply pumps that were mechanically economical and the situation would be very simple. The shaft is so small that large pumps and their pipes and appurtenances were difficult to handle, and at every 25 feet they would have to be stopped, disconnected, lowered and connected up again, which would have caused a great deal of delay, during which time large volumes of water are coming into the mine. Consequently, the situation came to be one where the system that would get the water out quickest and thus gain on the incoming water would probably cost least by the time the water was out, although perhaps costing more per foot gallon pumped.

With this idea in view, an air lift was installed at the 700-foot level of the Brunswick, to deliver water to the Cornish and also to an electric pump established on that station. An eight-inch water main was lowered on trucks down the shaft, as far as possible, to give submergence, and then a 2½-inch air pipe was lowered into this, and followed down at proper distances relative to the lowering water in the shaft. Air was turned on the 20th of last month, and has been operating without cessation. The quantity delivered was about 800 gallons per minute at the beginning, and on the 6th of this month, only sixteen days from starting, the 1,000-foot level was uncovered, and 250 gallons per minute were being delivered with a vertical lift of 300 feet and a submergence of only 230 feet. On account of the rapidity with which the water was lowered, this method was commercially very economical, and this simple and inexpensive arrangement is commended to others.

Rock drilling is one of the most expensive operations connected with mine development. Inasmuch as the power connected with it is one of the least expensive elements, and labor the greatest feature, the economical consideration is how to drill the greatest extent of holes with the least labor. There can be no doubt that in rock drills having the same stroke, diameter, and weight of piston, the one that gives the greatest number of uncushioned blows will do the most work. It will also take the most air per minute, but no more air per foot of hole drilled, and yet the labor in drilling the hole is less.

If one drill makes 500 blows per minute, and another 700, the relative striking force of the blow is not as 500 is to 700, but as $(500)^2$ is to $(700)^2$, or 25 to 49, practically double, because there are seven-fifths more blows moving seven-fifths faster, or forty-nine-twenty-fifths for the relative force. All of this difference

is not realized in work, but it indicates the proper direction for improved effect.

To obtain faster piston speed in a drill means that the proper air pressure must be delivered to the piston. This means proper initial pressure and proper pipes. From 50 to 60 pounds delivered at the drill is probably the average pressure. It should be 80 and 85, and better, 90 pounds. This will require not less than 90 to 95 pounds at the compressor.

The difference in power required to compress from 90 to 95 pounds is not in proportion to the pressure, but very much less, and the difference is so slight it may be neglected, yet that extra 5 or 10 pounds may offset the pipe friction and deliver a proper pressure to the drills.

It may be argued, and it is true, that it requires more repairs for drills when high pressure is used, rather than with a moderate pressure, and there are those who judge the virtue of a drill by its repair bill rather than by its record of holes drilled. Standard drills are so near alike that under similar conditions of operation the repairs will be nearly the same, and when they are up against hard rock a small repair account is not coincident with a large amount of work done. In fact, it is the reverse. Just why so much attention is paid to the repair account is a mystery, for it is an insignificant quantity compared to the other items which make up the cost of drilling holes.

Take an example of a baby drill in hard rock, making 33 1-3 feet each eight-hour shift, with $3 for the machine man, $1 per day for drill sharpening, $1 for power for each machine, and ½ a cent per foot of holes drilled for repairs. The total cost will then be: Labor $9, blacksmith $1, power $1, repairs $0.50, total $11.50, or 11½ cents per foot of hole. The drill repairs will then be $15 per month per machine, which is a liberal amount for a baby drill, and yet this is less than 5 per cent. of the total cost of drilling holes. It is evident that a reduction of air pressure to save a portion of this 5 per cent. would be poor economy, for a difference in work of one foot in every twenty would pay the entire repair bill. If a machine is well worn, and not doing good work, so that, for example, it falls behind the average but 5 or 6 feet of holes per day, it would pay to throw it away and put in a new machine, for in sixty days it would pay for itself.

In face of the large losses mentioned in connection with the power and leaky pipes, the small item of even apparently extravagant drill repairs may be overlooked. It is a paying proposition to carry high pressure and pay for the extra breakage. And, while on this subject, it might not be amiss to say that rock drill breakage under working conditions is expensive and annoying, but legitimate.

An engine is supposed to be so constructed that it will not break, and there is a large safety factor used in calculating its component parts, but in a rock drill, which is generally made of the strongest and most durable material, the safety factor must yield a second place to the consideration of weight, and hence the repairs.

In conclusion, it may be stated emphatically that the smaller plants have more to gain in proportion than the larger by using economical compressed air machinery, and that with a proper installation as much as 50 per cent. of this power bill could be saved in many instances. This saving would quickly pay for a proper plant, or it could be used to great advantage in additional development. There is a great demand for second-hand compressors for air lift pumping and for operating pneumatic tools, and no difficulty and very little loss would attend upon bettering the condition of an uneconomical compressed air mining plant.

The Ware Pneumatic Rail Unloader.

It is quite generally understood that rails are commonly shipped from rolling mills in gondola cars having the side and end boards permanently secured. In fact, much rail is shipped in deep steel cars, in which case it is impossible to remove the sides or ends of the cars for convenience of unloading. During the past few years the *Railway and Engineering Review* has closely followed the development of labor-saving machinery for handling rails, and from time to time articles have appeared descriptive of devices or machinery both for loading and unloading rails to and from cars of both the gondola and box type of construction, where access to the rails can be had at the end of the car

without lifting the rails, as is the case with gondola cars with removable ends and box cars with end doors. We now have information of a further improvement in rail-handling machinery along a slightly different line. Some time ago Mr. Henry Ware, roadmaster with the Buffalo, Rochester & Pittsburg Ry. at Springville, N. Y., designed apparatus for unloading rails from gondola cars with permanent ends. As this machinery has been in service a sufficient length of time to demonstrate its practicability and usefulness, an account of its operation is timely.

The machinery consists of two skids or incline troughs, over which the rails slide from the rear of the car, with pneumatic hoisting apparatus for lifting the rails from the pile in the car to the level of the skids. The apparatus is simple in construction, easily put into position for service, and the necessary manipulations are so simple that ordinary section men can handle it expeditiously. On each side of the car there is an upright, which is secured to the side of the car by means of an adjustable stake pocket and two adjustable brace rods. It can be placed on any kind of a car having open sides. The bottom of the upright is so formed that it rests on the car with sufficient stability to relieve any downward strain on the stake pocket. On the inside of each upright a roller is permanently secured at an elevation about 10 inches above the level of the top of the car, and there is also a roller at the top end of each skid or incline, which is hooked over the end of the car in line with the roller on the upright. The trailing ends of the skids are supported by a small piece of timber, about 5 x 5 inches, placed across the rails in the track. Each skid has an iron hook underneath, into which this piece of timber is placed. Attached to the under side of the piece of timber are two small wheels, so fixed that they gage with the track rails and thus hold the skids in position. All parts of the machinery are detachable and can be removed or attached without the aid of tools, except in the case of the stake pocket, which requires the use of a spike maul to drive the wedge which makes the adjustment of the pocket to the various width of the car sides.

The pneumatic hoists are suspended from a cross bar supported by the two uprights. The compressed air used is taken from the locomotive which handles the train, through the train brake line, being transmitted to the suspended air cylinders through a flexible hose of suitable length. In unloading rails three men are required to handle the rail and tongs, and one to manipulate the working of the air for the cylinder, on each side of the car, or eight men to unload and distribute rails from both sides of the car at the same time.

In operation the suspended tongs are attached to either the head or base of the rail, whichever is most convenient for grappling, and the rail is raised to a sufficient height to allow the men to guide it onto the roller attached to the upright and the roller at the head of the skid. The air is then released, the tongs detached and the men start the rails on the rollers toward the skid. When the centre of the rail reaches the roller on the skid the rail tips up, the end of rail slides to the ground, and as the train moves the upper end of the rail gradually reaches the ground or end of the ties without danger of damage to the rail or liability of its rolling down a high embankment. The men are not required to do any part of the lifting, that being done entirely by pneumatic power. The rails are landed on the ends of the ties, just outside of and clear of the service rails, without further attention after they enter the skids.

The cars are provided with permanent sides and end boards, 4 feet 5 inches high, inside measurement. From such cars it is not an easy matter to unload and distribute the heavy-section rails now generally used, even if permitted to drop them over the sides of the car by hand, which is considered bad practice, and often results in damage to the rails.

With the use of this apparatus each car, as it is unloaded, is cut off from the train and allowed to stand on the track while other cars are being unloaded, or until it is pushed to a siding by the regular traffic, when all the empty cars can be left on the siding or coupled in next to the engine and hauled along with the train. On some roads rails are unloaded with steam derricks or wrecking cars. In such cases the train is obliged to return to a siding after unloading each car ,in order to make a shift of cars to get the next car of rails to be unloaded ahead of the derrick. This

pneumatic unloading machinery used on the B., R. & P. Ry. obviates the necessity of running to sidings to shift cars.—*Railway and Engineering Review.*

Notes.

W. A. Gorman and R. H. Davis, of London, England, have secured English patents for certain improvements to air pumps which are designed to supply air to divers.

The Chattanooga Compressed Air Cleaning Company has recently started business at Chattanooga, Tenn. This company has a portable compressed air outfit and proposes to clean houses and carpets by the most improved methods.

The Economical Compressed Air and Sterilizer Company, of Milwaukee, Wis., has just been incorporated in that State. It has a capital of $20,000, and the incorporators are John Flenchan, W. R. Little and P. J. Savage.

J. Hosking, of Chudleigh, Devonshire, England, has secured an English patent for an improvement to a percussive rock drill. It is supplied with means for injecting water or some other liquid to the end of the bit for cooling it and removing the cuttings.

Jesse Gill, of Marysville, Ohio, has recently completed a new compressed air spray pump. By a system of cogs attached to the axle the pump receives its motion as the machine is wheeled along and compressed air is supplied to the tank containing the spraying solution. It is intended for use in orchards.

The Sacramento Compressed Air Cleaning Company has filed articles of incorporation in the State of California for the purpose of doing a general house, hotel and office cleaning business. Portable compressed air outfits will be used. The capital stock is $20,000, and the directors are Chauncey H. Dunn, Harry W. Rivett, M .V. Dunn, L. G. Rivett and S. M. Ford.

It is reported that the plan to connect the new custom house and the appraisers' warehouse in New York City by a pneumatic tube service, and the plan to build a similar service connecting the post office, court house and appraisers' stores at Chicago is held up. The comptroller of the treasury has reported that it will be necessary to insure the authority of Congress to install the systems.

Manufacturers of rock excavating machinery have been much interested to note the items which have appeared in the daily papers to the effect that the United States will begin work at once in building the Panama Canal and that the pay roll of the French company will be assumed. According to accounts the force of men will be increased as soon as new machinery can be secured.

Compressed air has been called upon to form the operating power for an ingenious contrivance called the pneumultiphone which will enable one man to play 24 musical instruments at once. It has 29 foot pedals, 35 push buttons, 35 stops, a quarter of a mile of rubber tubing, and over 100 valves to assist the player. The part of each instrument must be committed to memory by the player and each individual note must be played either by mouth, hand or feet. This device will, it is said, be exhibited at St. Louis this summer.

Among the recent English patents is one for an automatic vacuum brake. It consists of three chambers, the last of which is in communication with the train pipe and has a valve-controlled opening acting with the intermediate chamber which is itself in communication with the atmosphere. The upper chamber is in communication by a leakage passage with a lower chamber and is separated from the intermediate chamber by a diaphram

carrying the valve already mentioned which is firmly held on its seat by a spring in the upper chamber.

Peter Nissen, of Chicago, has invented a pneumatic barrel designed to sail on the water. The barrel is a curious contrivance 32 feet long and 22 feet in diameter, with a maximum circumference of more than 66 feet. It is shaped somewhat like a football. After being inflated by air it is expected that the wind will blow it across the water. Suspended from a shaft running through the barrel is a row boat in which the passengers ride. The boat is used so the passengers may be able to row ashore if anything happens to the barrel.

Differing from the usual automatic lubricator is an English invention to be used in connection with steam or air cylinders and is said to be particularly applicable to steam and pneumatic hammers or for other purposes where the work or movements of the parts to be lubricated is intermittent. This lubricator is said to be very convenient for use in such cases in that it allows easy introduction of oil in large or small quantities from any convenient place even into cylinders or other parts which are inconvenient to reach by reason of their height, position or otherwise.

An English patent for a pneumatic hammer provides for a machine, the chief new feature of which is an air inlet valve arranged on the pump cylinder at such a point that the entrance of air is cut off by the pump piston at about the commencement of the ascent of the ram piston. This is for the purpose of preventing the latter from drawing any air during its rapid ascent and so form a detrimental cushion of air in the ram piston. The loss of air in the ram piston is replaced by incoming air through the inlet valve in the air cylinder by the suction due to the stroke of the pump piston.

In a description of the mining department of the Hokkaido Colliery and Railway Company of Japan, in the May issue of *Mines and Minerals,* a description is given of the compressed air equipment at the mines of this company. At the Kamoi mine there is one air compressor which is used to drive regular drills, underground hoists and auxiliary fans. It is of the straight line pattern with piston inlet valves, made by the Ingersoll-Sergeant Drill Company. The steam cylinder is 24 inches in diameter, the air cylinder 24¼ inches in diameter by 30-inch stroke. The horizontal steel air receiver 48 inches by 12 feet is placed in the same engine house.

What exact advantage there would be in employing monkeys as divers it is difficult at present to say, but two learned professors have made what is regarded as an interesting discovery—viz., that whereas few divers can work at a greater depth than 100 feet, monkeys in dresses out of which the water is kept by compressed air show no signs of discomfort at a depth of 230 feet.

Animals can remain under water at this depth for four hours, and Professor Hill asserts that, with proper regulation of the length of shift and period of decompression, submarine work could be carried out at a depth of 200 feet.—*Daily Mirror* (Eng.).

In building the Bosruck Alpine tunnel, which connects Bohemia and the western provinces of the Austrian monarchy with the Adriatic, the question of power was an important one. The driving of the tunnel was begun in 1902 with hand drilling, but in order to complete it in time, power rock drills were used; a comprehensive hydraulic power plant was installed deriving its power from a mountain torrent. One of four turbines was used to operate a two-stage air compressor for the rock drills on the north side. Another supplied electric current at 6,000 volts to a transmission line about 4½ miles long, crossing the Bosruck summit to the southern end, where it was transformed to 220 volts continuous current to be used in driving rock drills.

The Hudson River Tunnel at Morton street, New York, affords an interest-

ing lesson in the improvement of air compressors since it was started thirty years ago, particularly as Ingersoll-Sergeant apparatus has been used from the outset. When the work was begun the machines were of the water-injection type, but as the construction proceeded they were replaced by compressors with poppet inlet valves and water-jacketed cylinders. When the Hudson Improvement Company resumed operations two years ago a better equipment was provided. On the Jersey shore there are four compressors, one a duplex machine with 16-inch steam cylinders, 20½-inch air cylinders and 16-inch stroke, and three straight-line machines with 22-inch steam cylinders, 24-inch stroke and 26¼ and 22¼ inch air cylinders. On the Manhattan shore there are two duplex compressors, like that on the other side, and a straight-line engine with 22-inch steam cylinders, 24-inch stroke and 22¼-inch air cylinders.—*Engineering Record.*

The principle on which the Parsons turbine acts when used as an air-compressor, says the *Scientific American*, is similar to that of the ordinary revolving disk fan, in which the velocity and volume of the current depend upon the size and angle of the vanes and their speed. If such a fan were placed inside a pipe approximately equal to its own diameter, and if there were no slippage between the air and the fan, the quantity of air moved per minute would be the product of the fan area, the pitch of its blades, and the number of revolutions per minute, from which data the velocity of the air current can also be computed. The pressure against which such a fan may work is proportional to the square of the maximum velocity. Owing to the inevitable slippage, however, the volume and velocity of the air current, calculated theoretically, must be multiplied by a coefficient which will depend upon the size, number and pitch of the vanes and the speed at which they are run. There is not yet any experimental data to determine what this coefficient may be for the Parsons turbine compressor, and the conditions are so widely different from those of ordinary fan practice that it is worthless to conjecture what it may be. The effect of the several rows of blades on the Parsons turbine, if the different rows are all set at the same angle, would be to reduce the slippage, and thus make possible the use of a very much higher pitch, producing a correspondingly higher velocity and pressure of air than would otherwise be feasible.

Of interest is a description given in the *"Engineer,"* an English publication, concerning the storage air brake installation recently made by the St. Louis Transit Company, of St. Louis, Mo. The lines and equipment of this company are described. Regarding the air brake system the *"Engineer"* says as follows:

"All the cars are equipped with air brakes, some operated from cylinders charged at certain points along the line, and others having motor-driven compressors on the cars.

"For the former, or storage system, there are eighteen air-compressing stations, located at points in the city and at the ends of the various lines, so that the cylinders can be charged while the car is waiting to start on a new trip. The compressors will be located in buildings, except in the residence districts, where they will be placed in underground chambers. The compressors will be of the Ingersoll - Sergeant compound - tandem type, with cylinders 6¼ inches and 14¼ inches diameter, 12-inch stroke. These will be driven from the motors by Morse silent chain gear. At each station will be two storage reservoirs 3 feet by 18 feet. Each car has two storage cylinders 1½ feet by 6 feet, for 20 cubic feet of air at 300 pounds pressure, which is reduced to a working pressure of 45 pounds in the service reservoir and brake cylinders. All the new cars are single-ended and run around loops—embracing two or more city blocks—at the end of the line. The front of the car is fitted with the Hunter safety fender, which is a crinoline frame of light steel straps, sloping down and out from the level of the window sill."

Thirty years ago work was begun on the first North river tunnel and the first connection between New York and New Jersey was established March 11, 1904, when one of the tubes extending under the Hudson river was completed.

The history of this tunnel has been somewhat checkered. When work was begun in 1874 compressed air was used with the system of tunneling employed, and was applied directly against the earth through which the tunneling was being done, as it was thought the air pressure would support the soft silt and keep out the water; but a cave-in was the result, 14 men dying without a chance to escape, and the project was abandoned as hopeless.

In 1890 a syndicate of English capitalists was formed and work was begun, but it was again abandoned upon striking a ledge of rock.

The next attempt to complete the tunnel was made in 1896 by William G. McAdoo, President of the New York & New Jersey Railroad Company, who organized a company to carry on the work. The old franchise rights and property were bought for a little more than $4.000,000 from the old Hudson River Company, which the English syndicate had organized. Mr. McAdoo also used compressed air, but at the end of the tube a shield was used which was pushed forward a distance of 36 inches at a time by means of hydraulic jacks. Charles M. Jacobs, also engineer of the Pennsylvania tunnel enterprise, has done the technical work of supervising the building of the tubes.

It is the north tube that has been opened, and the south tube is not far behind. The boring of the tubes was done by the shield process, most of it being through soft silt, although about 600 feet was through the rock ledge that conquered the English syndicate.

No animals have been allowed to enter the tunnel, the hauling of material being done by small cable cars; electricity has been used for illuminating. It is claimed by the engineer that compressed air work was never prosecuted with such speed, such freedom from accident, or with such comfort to the workmen. The tunnel is to be used for trolley cars solely. It can never be converted into a road for heavy trains, because it is not on a sufficiently firm foundation, having only the natural soil under the river to support it. It is promised that actual service through the tunnel will begin during the summer of 1905, and that the time between the New York and New Jersey side will be three minutes in running the distance, 1 7-10 miles.

A sister tunnel is to be built by the Manhattan & Hudson Tunnel Company between Cortlandt street, New York, and the Pennsylvania Railroad terminal in Jersey City. Mr. McAdoo is also the head of that enterprise, which is designed to benefit Pennsylvania passengers who prefer to reach downtown New York through the trolley tunnel rather than uptown New York through the railroad's own tunnel.

On March 11, 1904, the English contracting firm, S. Pearson & Son, Limited, of London, was awarded the contract for building four other tunnels under the East river for the Pennsylvania Railroad. The contracts for the North river tunnels between New York and Jersey City were awarded to the O'Rourke Engineering & Construction Company of New York. The work of digging is to begin within a month. The two North river tunnels will be 6,000 feet long, and each tube will be constructed of cast-iron, with steel construction at certain points. These tubes will be 23 feet in diameter and will be supported every 15 feet on cast-iron screw piles 3 feet in diameter. The greatest distance of the tubes below the surface of the bed of the North river will be 92 feet. The tunnel will be built on piles driven through the floor of the tunnel, the length of the piles varying from 10 to 150 feet. The piles will be riveted to the tunnel floor.—*Engineering Review.*

The London *Daily Times* has recently published a letter from Leonard Hill, M. B., F. R. S., regarding the disease which has affected men working under heavy air pressure. Divers' palsy he calls it, but in this country it is better known as "the bends." A more complete study

by Dr. Hill and an American expert will be published in the July number of COMPRESSED AIR. As the letter is an interesting one, it is republished here and will lend further interest to the article on the same subject in the next issue.

The letter is as follows:

"To the Editor of the *Times*—Sir: In the last few years there have been nearly 100 lives lost in the States from caisson illness. Such a death-roll signifies at least ten times as many cases of illness. This is a heavy addition to the already formidable list of deaths and illness resulting from caisson and deep-sea diving works. The increased death rate which follows increased depth of working at present prevents the execution of most important works, the bridging and tunneling of deep rivers, the recovery of cargoes from wrecks, and the raising of pearls and sponges from deep water. These works might be carried out safely if, with knowledge of the cause, the proper scientific precautions were taken to prevent illness. At present engineers are fearful of the risks of caisson work below a depth of 70 feet, and few divers attain to or exceed 100 feet. The caisson worker works in a chamber and the diver in a dress out of which the water is kept by compressed air. For every 33 feet of depth an air pressure of one atmosphere, or 15 pounds to the square inch, is required. Thus, a diver at 100 feet is exposed to four times the ordinary pressure of the atmosphere. Most writers on this subject have erroneously ascribed the illness to the mechanical effects of the pressure, and many strange devices have been tried to keep the pressure of the water off the body of the diver. As the compressed air presses equally on every part of the surface, and the fluids of the body equally transmit the pressure, the mechanical effect is *nil*. The real cause of the illness is the frothing off of air in the blood, a frothing which takes place when a man after exposure to compressed air is quickly 'decompressed' or returned to the normal atmospheric pressure.

"Under the ordinary air pressure each 100 cubic centimetres of a man's blood dissolves about 1 cubic centimetre of nitrogen, the same blood saturated under a pressure of four atmospheres, *e. g.*, at a depth of 100 feet, dissolves about 4 cubic centimetres of nitrogen. On rapid decompression each 100 cubic centimetres of blood will yield 3 cubic centimetres of gas, the gas escaping as bubbles, as in soda-water when the cork is drawn. The gas bubbles set free in the blood vessels obstruct the circulation, and may produce one or other of the protean symptoms which caisson workers and divers suffer from. One is struck with severe pain in the joints, another with some form of paralysis, others with deafness and vertigo, breathlessness, loss of consciousness, etc., while many escape owing to the lodgment of the bubbles in unimportant parts of the body. The gravity of the result depends on the height of the pressure, the length of exposure to the pressure, and the rapidity of decompression. Professor J. J. R. Macleod and myself have determined that animals can be exposed safely to 8 atmospheres (a depth of 230 feet) for four hours, if two hours be spent in gradual decompression. Monkeys exposed to this great pressure show no sign of discomfort, and, so far as we can learn, divers experience no more discomfort while in deep than in shallow water. We therefore are of opinion that by the proper choice of men, and regulation of the length of shift and period of decompression, submarine work could be carried out safely down to a depth of 200 feet.

"The diver Erostabe has actually salvaged treasure without losing his life from a depth of 180 feet. The men should be young, of spare habit, and abstinent. In the air-locks of caissons the process of decompression should be lengthened to a degree consonant with the depth of working, and a chamber should be at hand in which any man with signs of illness can be recompressed. Recompression drives the free gas bubbles again into solution. Such a chamber was introduced, with excellent results by Mr. E. Moir at the Hudson and Blackwall tunnels. At present the period of decompression is far too short, the workmen hastening it in order to get home. To procure the safety of divers, who ascend much too rapidly, Messrs. Siebe and Gorman have designed at my suggestion a diving bell to be used for

their gradual decompression. It is designed that the bell be lowered to the diver, so that he may enter it after completion of his work, and shut himself within an air-tight compartment provided with electric light, telephonic connections, etc. The pressure of the air within this compartment will be the same as that at which the diver is working. The bell will be raised on deck, and then the compartment will be gradually decompressed, an hour or more being taken for this process. I am confident that, with the aid of such a bell, wrecks may be salvaged and pearl and sponges raised at any depth up to 200 feet. Much beyond this depth we cannot hope to go, owing to the poisonous effect of the oxygen in highly compressed air.

"I am yours faithfully,

"LEONARD HILL, M. B., F. R. S.

"Osborne House, Loughton."

During the summer season at Proctor's Fifth Avenue Theatre, following the policy adopted last summer, there will be an elaborate system of revivals of the old standard comedy successes, as well as the presentation of some of the new pieces which have been recently reverted to stock company use. During the regular season it was found that the more varied bill is more acceptable to the audiences, but during the heated term comedy and comedy alone is demanded by the regular patrons, and catering to this demand, Mr. Proctor has arranged for an elaborate series of revivals, which will be presented by a thoroughly competent company, to which end several changes in the present personnel of the stock company will be made, to secure more satisfactory results in the comedy line. All the productions will be made with full scenic and costume equipment of the original wherever practicable, and where such are not obtainable the new production will be equally elaborate with the old.

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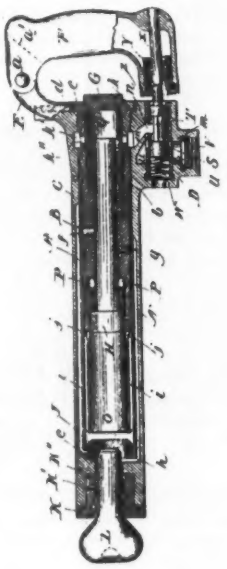
U.S. PATENTS GRANTED APR., 1904.

Specially prepared for COMPRESSED AIR.

756,357. PNEUMATIC HAMMER. Elias Gunnell, Chicago, Ill., assignor of one-half to W. I. Babcock, Chicago, Ill. Filed Dec. 17, 1900. Serial No. 40,078.



A pneumatic hammer, the combination, with the cylinder and the throttle valve controlling the admission of the motive fluid thereto, of a hinged grasping handle co-operating with said valve to open the same when the tool is held up to its work by pressure applied to said handle.

A pneumatic hammer, the combination of the cylinder provided upon one side of its rear end with the projecting arm or handle-support E, and upon the opposite side thereof with the casting D containing the throttle valve chamber, the throttle valve S located in said chamber and controlling the admission of the motive fluid to the cylinder, and the grasping handle F hinged at one end to the arm E and provided with a shoulder or contact surface b' co-operating with the like shoulder or contact surface a' upon the arm E, and co-operating at its opposite free end with the throttle-valve S to open the same.

756,469. PNEUMATIC MOTOR FOR AUTOMATIC MUSICAL INSTRUMENTS. Charles S. Burton, Oakpark, Ill., assignor to Melville Clark, Chicago, Ill. Filed Apr. 1, 1903. Serial No. 150,502.

A pneumatic motor comprising a crank-shaft having a plurality of cranks at intervals of less than one hundred and eighty degrees apart about its axis; a like plurality of pneumatics having their moving walls connected with the cranks respectively; valves which control the pneumatics respectively; a rock-shaft parallel with the crank-shaft having a lever-arm connected with the moving wall of the pneumatic at one end of the group, and a second lever-arm operatively connected with the valve for controlling the pneumatic at the other end, and sleeves mounted on the rock-shaft, having each two lever-arms connected respectively with a preceding pneumatic and the valve of a succeeding pneumatic.

756,484. AIR-PIPE-COUPLING PRESSURE-RELIEF VALVE. David W. Elliott and John B. Ruby, Newcastle, Pa. Filed Dec. 1, 1903. Serial No. 183,341.

An air-pipe-coupling pressure-relief valve, the combination with an angle-cock, having a hollow plug-valve provided with an additional or relief port arranged to communicate with the coupling-hose when said plug is turned to close the train-pipe, a relief-valve embodied in said angle-cock, said hollow plug-valve having a second relief-port admitting air from said plug and hose above said relief-valve, said angle-cock having a duct below said relief-valve open to the atmosphere, and hand-operated means for raising said relief-valve whereby said hose and plug may be discharged.

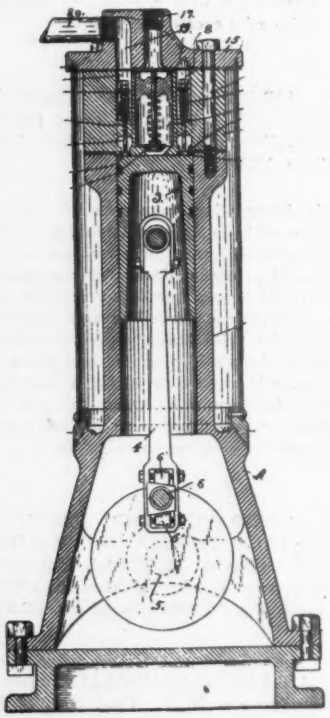
756,528. APPARATUS FOR PRODUCING ARTIFICIAL FOUNTAINS WITHOUT WATER. Clarence H. Roedel, Philadelphia, Pa., assignor to Edwin J. Jeitles, Philadelphia, Pa. Filed Aug. 18, 1903. Serial No. 169,903.

756,533. AIR-BRAKE MECHANISM. John R. Schrader, Buffalo, N. Y. Filed Nov. 18, 1902. Serial No. 131,839.

A brake mechanism, the combination of a valve-chamber, a cylinder connected at its inner end with the valve-chamber, a valve arranged in said chamber, a piston arranged in the cylinder and

connected on its rear side with the valve, guide-lugs arranged on the front side of the piston and engaging with the bore of the cylinder, a head closing the outer end of the cylinder and having a socket projecting inwardly therefrom, a graduating stem arranged in the socket and adapted to be engaged by the piston, a spring arranged in the socket and engaging with said stem for resisting the outward movement thereof, a stop applied to the inner end of the socket for limiting the inward movement of said stem, and steadying-lugs arranged on the inner side of the socket opposite.

756,529. GAS-COMPRESSOR FOR ICE-MACHINES. Samuel S. Rose, Amador City, Cal. Filed Mar. 12, 1902. Serial No. 97,839.



The combination in a gas-compressor for refrigerating-machines, of a vertically-disposed cylinder, a piston, a valve-casing containing intake and outlet valves seating on the upper end of said cylinder, a removable ring surrounding and supported on the base of said cylinder, a cylindrical casing 21 secured to said ring and inclosing and out of contact with the cylinder and valve-casing, a head or cap having inlet and outlet ports resting on said valve-casing and provided with an annular groove on its under side to receive the upper end of said casing 21, and means for locking the said several parts rigidly together.

756,604. AIR-BRAKE. Dennis Dunn, Mahanoy City, Pa., assignor of one-half to James H. Prosser, Mahanoy City, Pa. Filed June 23, 1903. Serial No. 162,710.

An auxiliary air-brake device comprising a cylinder, a piston in said cylinder, a valve controlling the exhaust from the brake-cylinder connected to said piston, pipes connecting each end of said cylinder with the train-pipe and a valve in one of said pipes adapted to be seated by excess pressure in said cylinder, whereby exhaust from the brake-cylinder is controlled by variation in train-pipe pressure.

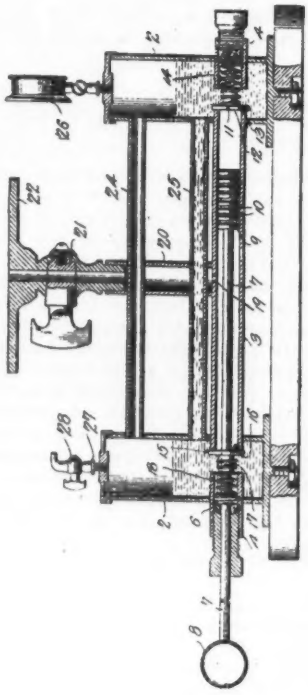
756,643. AIR COOLER AND FILTER. John Jester, St. Joseph, Mo. Filed June 22, 1903. Serial No. 162,682.

756,736. MACHINE FOR LOADING RAILS. Frank Thompson, Chicago, Ill., assignor to United Supply & Manufacturing Company, Chicago, Ill., a Corporation of Illinois. Filed Aug. 19, 1903. Serial No. 170,017.

A rail-loading mechanism, the combination of a flat-car or truck movable from car to car of a train, a boom pivotally mounted, an upright consisting of a fixed section and a movable section, a hinge-joint connecting the two sections of the upright, supports for the movable section of the upright adapted to hold the same in fixed upright position and adapted to be unfastened from the upright to allow the same to be lowered, a hoisting-engine adapted to co-operate with the upright and boom, and a pressure-supply pipe for the hoisting-engine adapted to be connected successively with the train-pipes of the cars, substantially as described.

756,776. SEED-COTTON DISTRIBUTER. Monroe C. Brown, Austin, Tex. Filed Mar. 7, 1903. Serial No. 146,749.

756,630. AIR-PUMP. Justin S. Hemenway, River Falls, Wis. Filed June 12, 1903. Serial No. 161,246.



The combination in an air-pump of an open-ended cylinder having an inlet-opening intermediate of its ends, oil-receptacles within which the ends of said cylinder are located, a pipe connecting said oil-receptacles, valves within said oil-receptacles to keep the ends of said cylinder normally closed, and a piston mounted for reciprocation within said cylinder.

756,791. GOVERNOR FOR HYDROPNEUMATIC ENGINES. Ernest A. Hornbostel Jr., Des Moines, Iowa. Filed Mar. 27, 1903. Serial No. 149,775.

A hydropneumatic engine containing a reciprocating piston and also a reciprocating float, a rotatable crank-shaft, a balance-wheel on one end portion of the shaft, two levers fulcrumed to the balance-wheel to project in reverse ways relative to each other and the axis of the shaft, weights on the ends of the long arms of the levers, an evener pivotally connected with the hub of the balance-wheel to vibrate concentrically with the axis of the shaft, links connecting the ends of the evener with the short arms of the levers and means for normally retaining the weights on the ends of the long arms of the levers at the central portion of the wheel, a rock-shaft in parallel position with the crank-shaft, an arm extended from the end of the rock-shaft, a link pivotally connected with said arm and with one end of said evener, an arm at the centre of the rock-shaft and a stem pivotally connected with said arm and with the float, arranged and combined to operate in the manner set forth for the purposes stated.

756,929. PNEUMATIC SWITCH AND SIGNAL APPARATUS. William J. Becker, Milwaukee, Wis. Filed Nov. 3, 1902. Serial No. 129,873.

A power switch or signal apparatus, a switch or signal, a power-supply for said switch or signal and means actuated by atmospheric pressure against a vacuum to release said power-supply to operate the switch or signal.

The combination in a pneumatic relay-valve for controlling the admission of air at a pressure different from that of the atmosphere, of a valve-casing provided with suitable inlet, outlet, and exhaust ports, and with valve-seats, an admission-valve body and an exhaust-valve body connected to move together and to suitably control communication between said ports, a diaphragm operated by air at a pressure also different from that of the atmosphere, but on the other side of the atmospheric pressure-line from the pressure controlled by the valve, a stem projecting from the exhaust-valve body through the casing, a plate on the diaphragm, rods projecting from said plate outside of the ports, and a cross-bar attached to the rods and in line with the exhaust-valve stem for operating the valve-bodies from the diaphragm through the stem, and a hood attached to the casing to protect the projecting parts.

757,015. STRAIGHT-AIR AUTOMATICALLY-ACTING BRAKE. John H. Bleoo, Brooklyn, N. Y., assignor to Abraham B. Levy, New York, N. Y. Filed June 12, 1902. Serial No. 111,322.

An air-brake system for single cars the combination of a brake-cylinder, a controlling-valve and a governing-valve of the triple-valve type, a reservoir C, and pipe connections all connected in such manner as to receive pressure from a single source and to maintain the same given air-pressure throughout the system when the parts are in the release position, means for maintaining said given predetermined air-pressure throughout the entire system, hereinbefore specified, an automatically-unseated valve normally balanced when the air-pressure is normal and adapted to be seated upon leakage of air-pressure from one side thereof, means for supplying straight air to the brake-cylinder operative upon a movement of the automatically-unseated valve and an automatically-seated valve operative upon reduction of the air-pressure, whereby upon breakage or excessive leakage in the system the brake will be automatically set.

757,016. TRIPLE VALVE FOR AIR-BRAKE SYSTEMS. John H. Bleoo, New York, N. Y., assignor to Abraham B. Levy, New York, N. Y. Filed June 11, 1903. Serial No. 161,003.

757,066. PNEUMATIC TYPE-WRITER WITH OPEN-PIPE SYSTEM. Maximilian Soblik, Dusseldorf, Germany. Filed Oct. 29, 1902. Serial No. 129,188.

A type-writer, a series of perforated keys, a perforated ring connected thereto, a rotable hollow arm movable along the surface of said ring, a pair of air-ducts, and means on said arm for connecting said air-ducts, substantially as specified.

757,177. PNEUMATIC MASSAGE APPARATUS. Frederick H. Crabtree, Anaconda, Mont. Filed Nov. 18, 1903. Serial No. 181,611.

757,188. PNEUMATIC STRAW-STACKER. Thomas Goodale, Wadena, Minn. Filed Oct. 29, 1903. Serial No. 178,970.

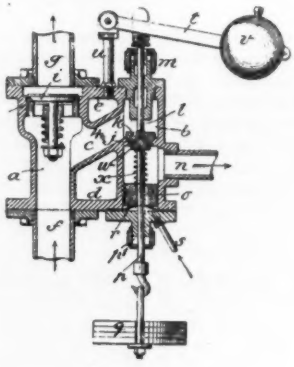
757,571. AIR-VALVE FOR SAFETY TRAIN-STOPS. Hiram G. Sedgwick, New York, N. Y. Filed Aug. 24, 1903. Serial No. 170,517.

An air-valve for automatic train-stopping apparatus, comprising a valve-chamber adapted to be connected to the train-pipe of the air-brake system, a valve therein, mechanism connected to and adapted to automatically move said valve to successively vent the train-pipe, and means adapted to be engaged by a roadbed device to set said valve-moving mechanism in operation.

757,881. REDUCING-VALVE. James J. Burke, Hartford, Conn. Filed June 25, 1902. Serial No. 113,094.

The combination, with a tube having an intermediate valve-chamber, and provided with an unobstructed extension on each side of said valve-chamber, of diaphragm-chambers, one located at each end of said tube; flexible diaphragms covering said chambers; chambered caps removably secured to the chambers, and serving to connect the diaphragms thereto; a spring bearing against one of the diaphragms; means for regulating the tension of said spring; a high-pressure pipe communicating with the valve-chamber; a valve-rod passing through the tube and valve-chamber and secured to the diaphragms, a valve on said rod, co-operating with a port of the valve-chamber; a low-pressure pipe connected to the tube; and a pipe leading from said low-pressure pipe and entering the cap of one of the diaphragm-chambers.

757,901. UNLOADING DEVICE FOR AIR-COMPRESSORS. William S. Fairhurst, Brooklyn, N. Y., assignor of one-half to John J. Riley, Brooklyn, N. Y. Filed Apr. 29, 1902. Serial No. 105,134.



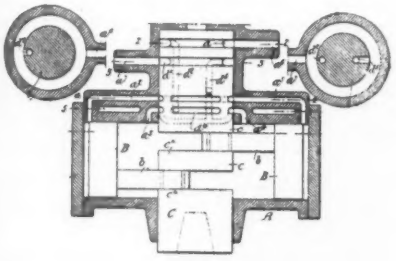
An unloading device for a compressor, a chamber in the lower part of which is a cylinder, an

upwardly-opening relief-valve and a seat therefor in said chamber above said cylinder, a piston in said cylinder, the piston being of larger area than the said valve, a communication between the outlet of the compressor and said chamber above said valve, an escape-outlet to the atmosphere from said chamber between said valve and piston, a communication between the receiver of the compressor and the space below its piston, a loading device applied to said valve for closing it, a spring between the piston and valve for opening the latter, and a loading device applied to said piston and acting thereon in opposition to the pressure in the receiver, substantially as herein described.

758,058. TIRE-INFLATOR. Fernando H. Geisler, Dayton, Ohio. Filed Mar. 18, 1903. Serial No. 148,438.

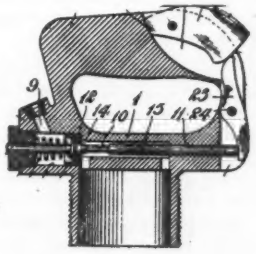
A pump for pneumatic tires, the combination with a wheel and a frame, to which it is secured, of a pump-cylinder fixed to the wheel, a piston in the cylinder, a piston-rod extending beyond the end of the cylinder, a plate fixed to the wheel and formed with a guideway through which the piston-rod moves, a lever fulcrumed on the plate and engaging the piston-rod, a spring engaging the plate and lever to force the latter in one direction, and means on the frame engaging the lever to move the same against the force of the spring.

757,970. PNEUMATIC TOOL. Willard T. Sears, Harrisburg, Pa. Filed Sept. 4, 1903. Serial No. 172,014.



The combination in a pneumatic tool of a cylinder, a crank-shaft, a piston in the cylinder connected to the shaft, said cylinder having ports for the admission and exhaust of motive fluid, said ports being placed to permit the said fluid to act on both faces of the piston, the crank-shaft also having in it passages for controlling said fluid, said passages being formed to coact with the ports of the cylinder, substantially as described.

758,100. HANDLE FOR PNEUMATIC TOOLS. Caid H. Peck, Waverly, N. Y., assignor to Imperial Pneumatic Tool Company, Athens, Pa., a Corporation of New York. Filed Jan. 16, 1904. Serial No. 189,331.



A pneumatic tool, the combination with a head-block having an air-inlet duct therein, of a valve mounted in said head-block controlling said air-duct, a handle connected to said head-block, an operating-lever mounted in said handle and having a wedge-action cam-face, and an intermediate lever between the stem of said valve and said operating-lever aranged to engage said cam-face and be operated by the wedge action thereof.

758,118. SAND-BLAST. Francis Sticker, New York, N. Y. Filed May 29, 1903. Serial No. 159,354.

A sand-blast, a sand-receptacle, a pipe leading therefrom having a mixing-chamber, an air-supply leading to said receptacle and chamber, and means for controlling said supply whereby it may be directed only to the receptacle, or to the receptacle and such chamber.

A sand-blast, the combination with the sand-receptacle having an outlet, a discharge-pipe leading therefrom said pipe having enlarged portions forming mixing-chambers, and a tubular rod having inlet and outlet ports and carrying a valve designed to extend into said pipe and regulate said outlet, said valve having a passageway, of a pressure-supply pipe having three branches leading respectively to said tubular rod and to said chambers, the nozzles of the branches leading to the chambers being extended into the latter, and

a cock in said supply-pipe having ports designed respectively to register with said branches, whereby a partial turn will supply air to said rod, a further turn supply air to one of said chambers, and a still further turn supply air to the other of said chambers, the previously created supplies being maintained during the establishment of communication with each of said chambers.

758,173. EMERGENCY-BRAKE. Fred B. Corey, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed Oct. 14, 1903. Serial No. 177,048.

In combination, an automatic air-brake system, an engineer's valve, a source of compressed-fluid supply, and an emergency device constructed and arranged to connect the train-pipe of said system to atmosphere to apply the brakes and simultaneously to cut off communication between the train-pipe and the source of supply without interfering with the connections between the engineer's valve and the braking devices of the system.

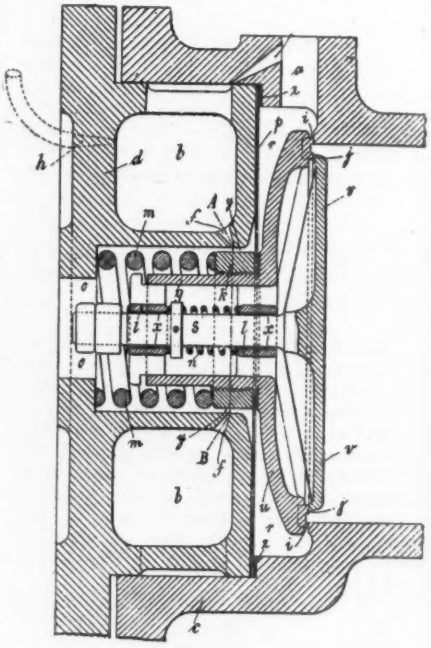
758,174. AIR-BRAKE CONTROLLING VALVE. Fred B. Corey, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed Nov. 20, 1903. Serial No. 182,035.

758,297. RAILWAY SIGNAL APPARATUS. Clarence W. Coleman, Westfield, N. J., assignor to the Hall Signal Company, a Corporation of Maine. Filed Apr. 4, 1902. Serial No. 101,327.

A fluid-pressure signal apparatus, the combination of a signal; a continuously-maintained fluid-pressure-supply source; a fluid-pressure-applying chamber in operative connection with the signal and in communication with said supply source; supply and exhaust valves for said chamber; means for operating said valves whereby fluid-pressure may be supplied to and maintained in said chamber to move the signal from one position to another and there maintain it by said fluid-pressure; and a retaining device to prevent return movement of the signal.

758,336. PNEUMATIC-TIRE COVER. George T. Shilton and Albert Schultze, Greymouth, Westland, New Zealand. Filed Aug. 25, 1903. Serial No. 170,662.

758,183. CONCENTRIC VALVE FOR COMPRESSOR-PUMPS. Albert Kryszat, Berlin, Germany. Filed Oct. 24, 1902. Serial No. 128,625.

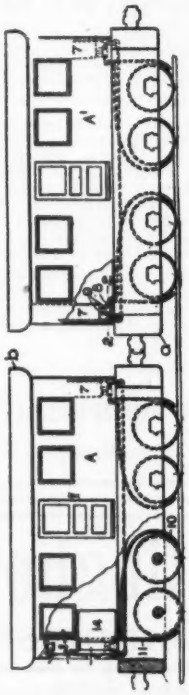


In combination with a compressor-pump, a pair of valves arranged within the end of the pump-cylinder partly within the admission-chamber, a diaphragm supporting the outlet-valve *u*, a sleeve connected to said valve having play (at *y*) inside the surrounding wall of the admission-chamber, bearing-eyes in the sleeve, a stem *s* forming part of the inlet-valve *v*, said stem extending through the said bearing-eyes and having play (at *x*), the valve *v* being seated concentrically within the valve *u*.

758,453. PNEUMATIC SHEET-FEEDER. Alexander Lagerman, Jonkoping, Sweden. Filed Jan. 31, 1903. Serial No. 141,284.

A pneumatic sheet-feeding mechanism having a mouthpiece with a substantially flat face, and said mouthpiece pivotally mounted with the pivotal axis in the same plane with the said face, whereby the latter may be adjusted on its pivot to an angle with the surface of the sheet to be separated proportional to the stiffness of said sheet.

758,194. SANDING SYSTEM. William Schaake, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed Sept. 28, 1903. Serial No. 174,896.

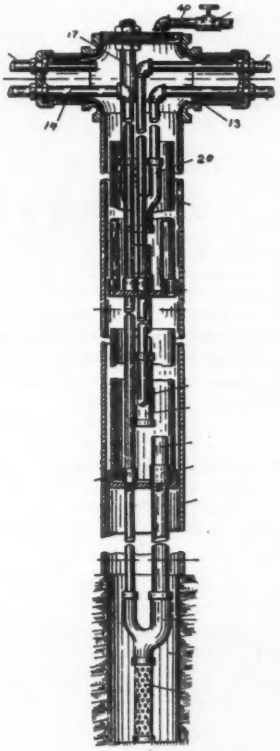


A locomotive equipped with a plurality of pneumatically-actuated sanding devices adapted to deposit sand in front of the driving-wheels of said locomotive for either direction of movement, and electrically-operated means for independently controlling the operation of the sanding devices which deposit sand in front of the wheels when the locomotive is moving in one direction and the sanding devices which deposit sand in front of the wheels when the locomotive is moving in the opposite direction.

758,360. AIR OR GAS LIFT FOR FLUIDS. Walter B. Harris, Indianapolis, Ind. Filed July 6, 1903. Serial No. 164,358.

An air or gas lift for fluids, including an air-tight casing, an ejector that tends to draw up fluid from below and to force the fluid above it out of the casing, and means for introducing compressed air or gas into the casing upon the body of fluid therein to co-operate with said ejector.

An air or gas lift for fluids, including a delivery-tube, a compressed-air pipe and an ejector connecting the compressed-air pipe with the delivery-tube, said ejector having an outlet passageway connecting with the delivery-tube, a compressed-air passageway leading from the compressed-air pipe and that is partially parallel with the outlet passageway, an inlet passageway leading to the outlet passageway, and a partition between the compressed-air passageway and the inlet passageway extending to the outlet passageway so that the latter part of the compressed-air passageway is parallel with the latter part of the inlet passageway, and all parts of said ejector being formed integral.



An air or gas lift for fluids, including an air-tight casing, a comparatively short cylinder in

the casing of smaller diameter than the casing and with its upper end opening into the casing to act as a receiving-chamber for the fluid, and means for elevating the fluid first into said cylinder and then from said cylinder out of the casing, and means for introducing compressed air or gas into the upper end of the casing so it will press down upon the fluid in the cylinder and also pass the cylinder.

758,427. TRAIN-PIPE-TESTING DEVICE FOR AIR-BRAKES. William S. De Camp, Chillicothe, Ohio. Filed Jan. 19, 1904. Serial No. 189,682.

A testing device for an air-brake and signal system, consisting of a valve mechanism constructed to connect the air-brake pipe and whistle-pipe at their rear ends, by which the signal-whistle is operated through the air-brake pipe when both are in operative condition, and a rear signal-whistle located in that portion of the device directly connecting with the air-brake pipe to signal danger in backing up the train, substantially as described.

758,516. AIR-PUMP. John E. Fisher, New York, N. Y. Filed May 15, 1901. Renewed Sept. 10, 1903. Serial No. 172,571.

An air-pump, the combination, with a handle-section, of a tubular piston-rod located in the same and provided at its outer end with a backwardly-turned portion located beyond the side of the handle-section, and a flexible connecting-tube connected with said backwardly-turned portion and adapted to lie alongside said handle-section, substantially as set forth.

758,569. PNEUMATIC-DESPATCH APPARATUS. Charles F. Stoddard, Boston, Mass., assignor to American Pneumatic Service Company, Dover, Del., a Corporation of Delaware. Filed May 7, 1903. Serial No. 155,990.

An apparatus of the character described, a terminal, and valves located in said terminal and adapted to be opened for the passage of the carrier by the carrier and having their greater area located out of the line of travel of the carrier and in the same plane as the smaller area.

758,606. PNEUMATIC STRAW-STACKER. James A. Walsh and Eugene Bretney, Indianapolis, Ind. Filed Aug. 17, 1903. Serial No. 169,799.

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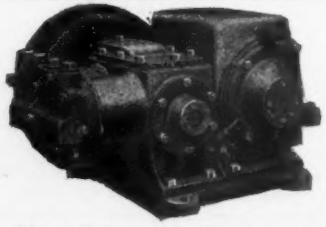

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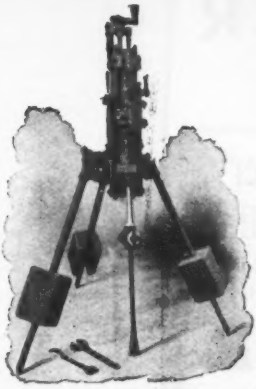

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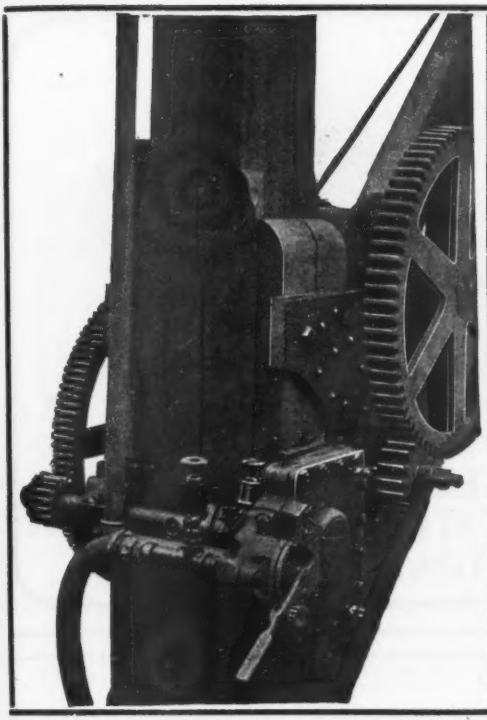

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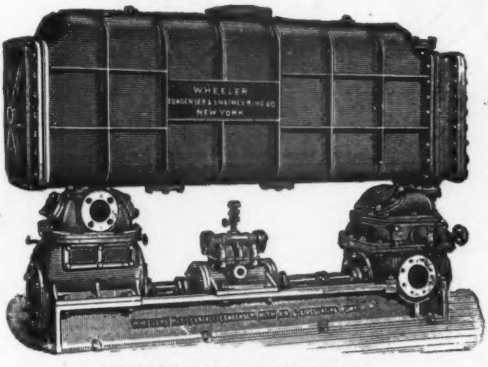

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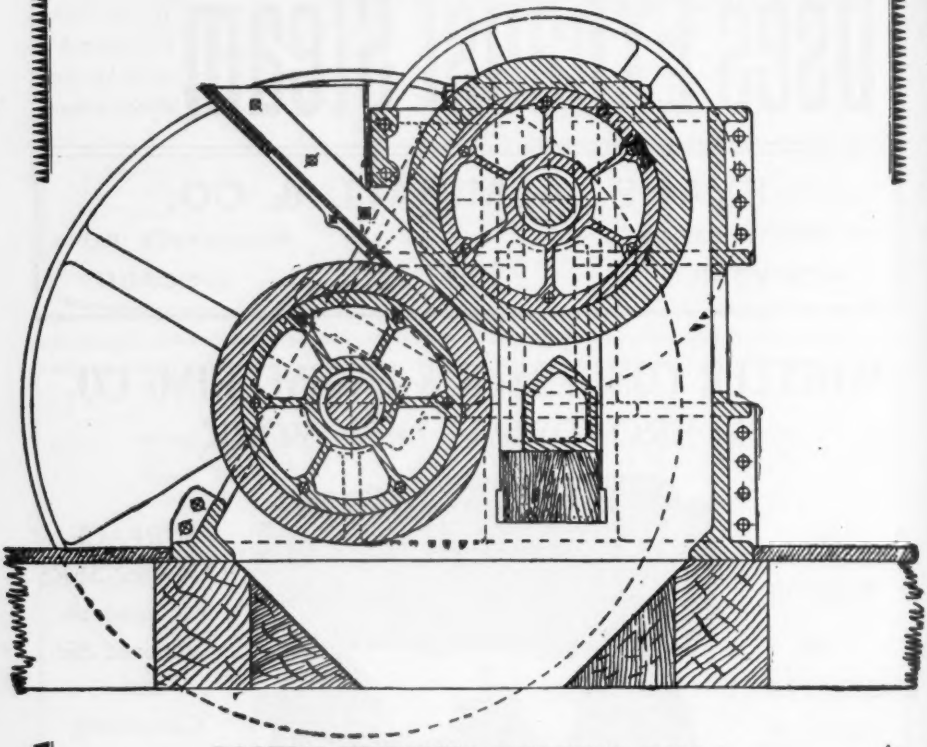

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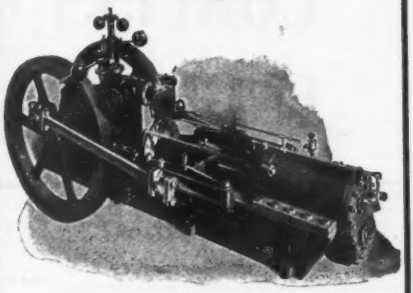

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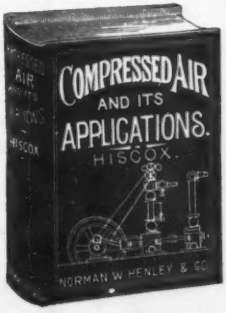

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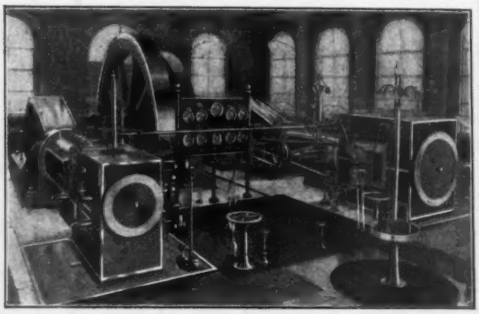

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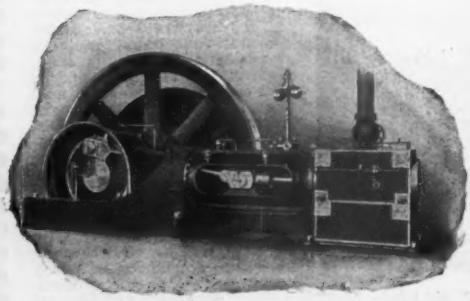

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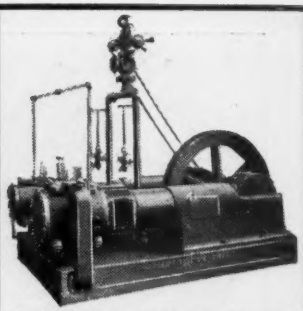

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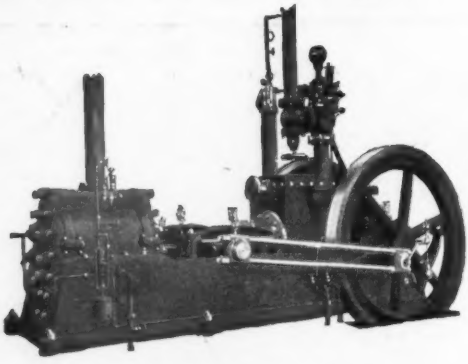

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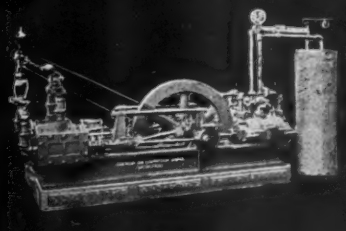

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